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DEPARTMENT OF THE INTERIOR—U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

A GEOLOGICAL RECONNAISSANCE IN NORTHWESTERN OREGON

BY

JOSEPH SILAS DILLER

EXTRACT FROM THE SEVENTEENTH ANNUAL REPORT OF THE SURVEY, 1895-96
PART I—DIRECTOR'S REPORT AND OTHER PAPERS.

WASHINGTON
GOVERNMENT PRINTING OFFICE
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A GEOLOGICAL RECONNAISSANCE IN NORTHWESTERN OREGON.

By J. S. Diller.

INTRODUCTION.

Coal has long been mined at one place in northwestern Oregon, and has been reported from many others. Gold and other minerals have been found in the same region, and on account of their bearing upon the economic interests of the State, the Director of the Geological Survey instructed the writer to make a general reconnaissance of that portion of the country with special reference to its mineral resources. The results will be considered under two general heads: Part I, Historical and Structural Geology; Part II, Economic Geology.

PART I.

HISTORICAL AND STRUCTURAL GEOLOGY.

ROUTE OF TRAVEL.

A camping party, consisting, besides the writer, of an assistant, a packer, and a cook, outfitted a pack train at Forest Grove, west of Portland, in Washington County, and crossed over the divide to the coal fields of the Upper Nehalem, east of Vernonia, in Columbia County. The route, which is indicated upon the map, Pl. I, continued down the river to beyond Mishawaka and crossed the military trail by way of Saddle Mountain to Astoria. The coast roads and trails were followed south to the Lower Nehalem coal field and Tillamook, where the party divided to return to Forest Grove by different routes, F. M. Anderson crossing the range by the Trask River stage road, and the writer, with the main party, returning by way of Wilson River.

Starting from Forest Grove a second time, the party moved by wagon, camping by the way, to Corvallis, and crossed the Coast Range to the Yaquina coal field and the coast, returning to Corvallis by the Elk Creek road. The route continued southward to Harrisburg, where the party was in part disbanded and gave up camping to live with the people. Work was continued in the vicinity of Roseburg and westward along the several roads to the coal fields of Coos Bay.

TOPOGRAPHY OF WESTERN OREGON.

Along the coast of Oregon and California, from the Columbia to near the boundary of Mexico, there is a prominent range of mountains known generally as the Coast Range. The essential continuity of this range, as well as its distinctive parts, was long since pointed out by Professors Dana[1] and Newberry.[2] In middle California and northern Oregon, where the range is bounded on the east by a great valley, it is distinct, and these portions are readily distinguished, respectively, as the Coast Range of California and the Coast Range of Oregon. But between them, in northwestern California and southwestern Oregon, there is a large complex group of mountains, in which the Cascade, Sierra Nevada, and the Coast Range appear to meet. This irregular group contains many individual ridges and peaks, as, for example, Yallo Bally, Bully Choop, Salmon, South Fork, Trinity, Eddy, Scott, and Marble Mountain in California, as well as Siskiyou, Rogue River, Umpqua, and other mountains in Oregon. Upon geological grounds it appears that this group of mountains belongs to the Coast Range rather than to the Sierra Nevada or Cascade Range, and needs a special name to distinguish it from the Coast Range of Oregon on the north and the Coast Range of California on the south. For this reason this group has been designated the Klamath Mountains, after the principal river which cuts through these mountains to the sea.

The Klamath Mountains of Oregon extend northward from the southern boundary to about the Middle Fork of the Coquille. Beyond that point the Coast Range of Oregon stretches away to the Columbia.

The reconnaissance outlined in these pages extended throughout the Coast Range of Oregon and touched at a few points upon the northern border of the Klamath Mountains and the western foot of the Cascade Range. In the accompanying map, Pl. IV, the route is illustrated.

FEATURES OF THE COAST RANGE OF OREGON.

The Coast Range of Oregon is an irregular ridge or series of ridges with bold lateral spurs, especially on the ocean side. It varies much from place to place, yet nowhere does it attain a great altitude. The elevations of its summits have not yet been accurately determined anywhere, and only in a few places has the height of peaks been even approximately measured. Saddle Mountain, which is a rugged summit seen to the southeast from the Astoria, has a bold peak outlined against the sky, and attains an altitude (aneroid) of over 3,325 feet. Of this view Professor Dana[1] remarks that "there was one broken summit to the southeast, calculated to engage the attention; it is called by the Indians Swàlalàhos, and has also been named Saddle Hill."

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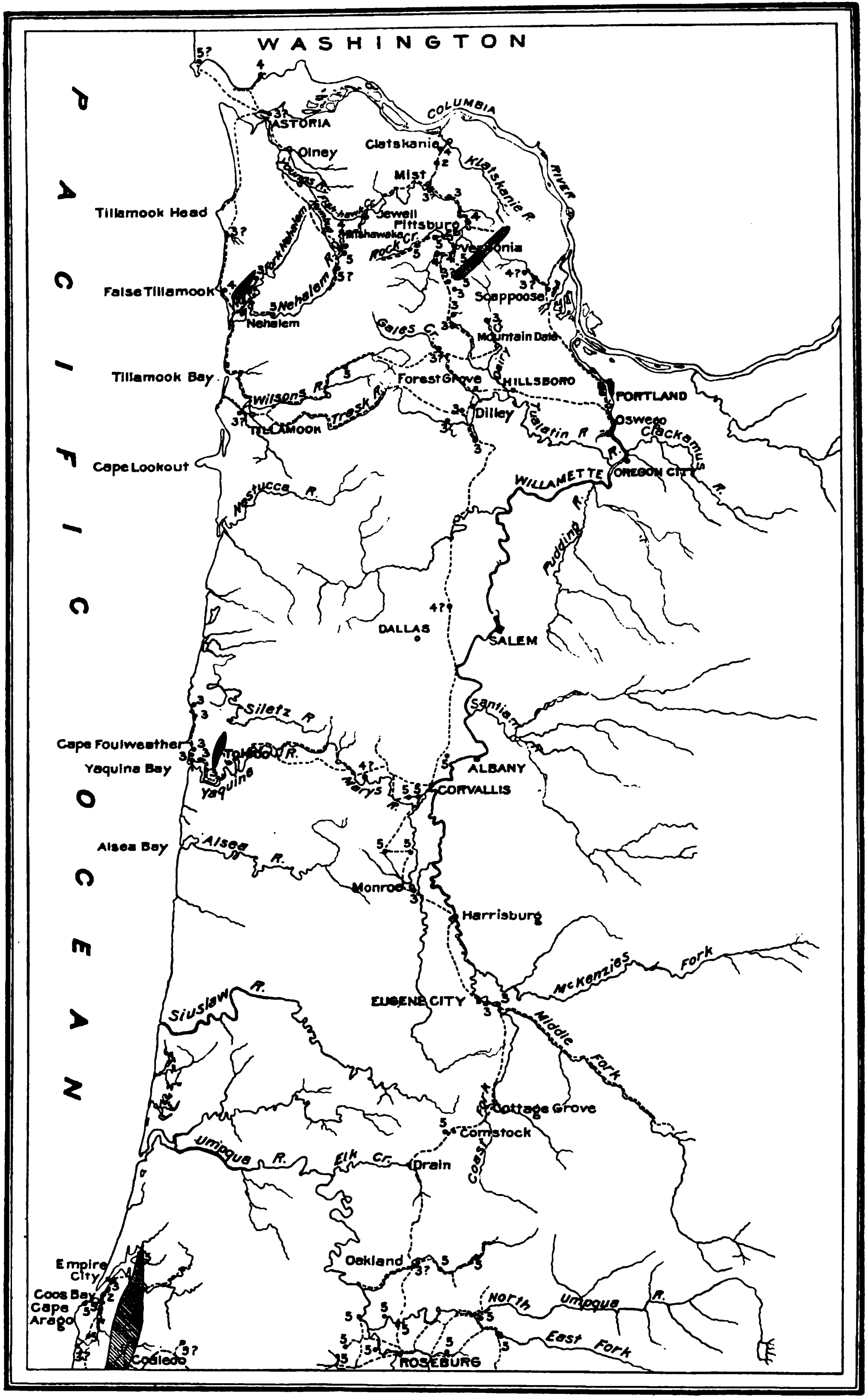
[1] Wilkes Exploring Expedition, Vol. X, p. 615.

[2] Pacific Railroad Survey, Vol. VI, Pt. II, p. 29.



MAP OF NORTHWESTERN OREGON, SHOWING ROUTE.

The route of travel is indicated by a broken line. The dark-lined inclosed areas represent coal fields. The numbered dots indicate localities where fossils were found; 1 = Pleistocene, 2 = Pliocene, 3 = Miocene, 4 = Oligocene, 5 = Eocene.

Onion Peak, farther westward, is of nearly equal height. Both are old volcanoes and belong to the volcanic ridge which runs transverse to the general trend of the Coast Range. As shown in Pl. V, it begins at the west, in the Ne ah kah nie Mountains, just north of the mouth of the Nehalem, and stretches northeast through Union Peak, Saddle Mountain, and other summits, to the Columbia, near Westport. The bold escarpment of the north bank of the Columbia at this point belongs to the same line of elevations extending into Washington.

A noteworthy feature of this ridge, especially about Saddle Mountain, and to a less extent also through portions of the Coast Range, is the occasional occurrence of comparatively even table-lands, above which the peaks and upper mountain slopes rise rather abruptly.

At the head of the Nehalem is Round Top, and farther south, on the Trask, is Larch Mountain, which was reported to Mr. Anderson as being 3,500 feet high. Euchre Peak, near the head of the Siletz, according to Mr. C. B. Crosno, of Toledo, is probably the highest peak of the range, and attains an altitude of 3,962 feet. Marys Peak, south of the Yaquina, is prominent, as seen from the eastward near Corvallis, and in elevation may be nearly equal to or even greater than any of those already mentioned. Farther southward the Coast Range touches the Calapooia Mountains, a spur of the Cascade Range, and on the Coquille passes into the Klamath group. The general elevation of the mass and its tabular feature increase southward, but individual peaks are less prominent. Throughout its whole length the slopes of the Coast Range in Oregon are of unequal length. The watershed lies nearest the eastern side of the range. The spurs running out from the summit of the range to the sea are long and of gentler descent than the shorter spurs, which extend toward the Willamette Valley.

At two points in its course, between the Columbia and the Coquille, the Coast Range is transsected by rivers—the Nehalem near the northern end and the Umpqua in the southern third.

The Nehalem rises upon the eastern slope of the Coast Range, and by a fine curve of over 50 miles to the northward it returns against the range and in a southwesterly direction cuts through it, near the Saddle Mountain ridge, to the sea. The stream is small, and the canyon it has cut across the range is deep and long.

The Umpqua is a larger stream, deriving much of its water from the Cascade Range. It flows northwesterly to near the Calapooia Mountain, where it turns abruptly westward and cuts through the Coast Range to the ocean.

At two other points there are low gaps across the range. One is at the head of the Yaquina River, where the Oregon Central and Eastern Railroad crosses the summit at an elevation 720 feet above low tide in Yaquina Bay; and the other is on the Suislaw, which practically cuts entirely through the Coast Range, but reaching the point where that range touches the Calapooia Mountain, it fails to meet a low valley. The eastern base of the range at Summit, on the Oregon and California Railroad, between Cottage Grove and Drain, has an elevation of 779 feet.

FEATURES OF THE OREGON COAST.

The coast of Oregon is made up of long stretches of sand beach, interrupted here and there by prominent headlands of hard, igneous rocks, which stand out boldly to sea as if to defy the waves and impede coastwise traffic.

The beaches are remarkable for their solidity and beauty, as well as their strong, cool, summer winds which afford complete relief from the heat of the interior valleys. Clatsop Beach, along the northwest shore of the county of the same name, and Nye Beach, near Yaquina Bay, are the most frequented, and are justly celebrated on account of the attractive camps which their clustered pines afford.

Clatsop Beach is especially remarkable on account of its sand ridges, which extend with striking uniformity for nearly a dozen miles along the coast, and carry the Necoxey River for almost the whole distance to the beach. Nearly midway between Astoria and Seaside the profile of these ridges appears as in fig. 4.

The road runs along the crest of the ridge and affords a fine view. There are usually three ridges, nearly parallel and remarkably even and regular. They are composed, at least in large part, of sand, and are covered by a dense growth of grass and ferns. The western slopes are gentle, but to the landward the incline is 40 degrees. The first ridge is one-third of a mile from the beach, above which it rises about 30 feet; the other two are not quite so high nor so regular. They appear to be simply dune sand ridges, and owe their regularity in large measure, no doubt, to the regularity of the winds and the sand supply. Similar small ridges were seen also at other places, but they were less regular and extensive. Several miles north of the mouth of Tillamook Bay such ridges inclosed lakes of considerable size close to the beach, and the only outlet was by filtration through the barrier.

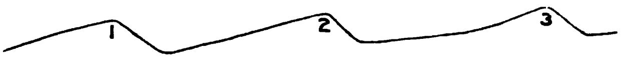
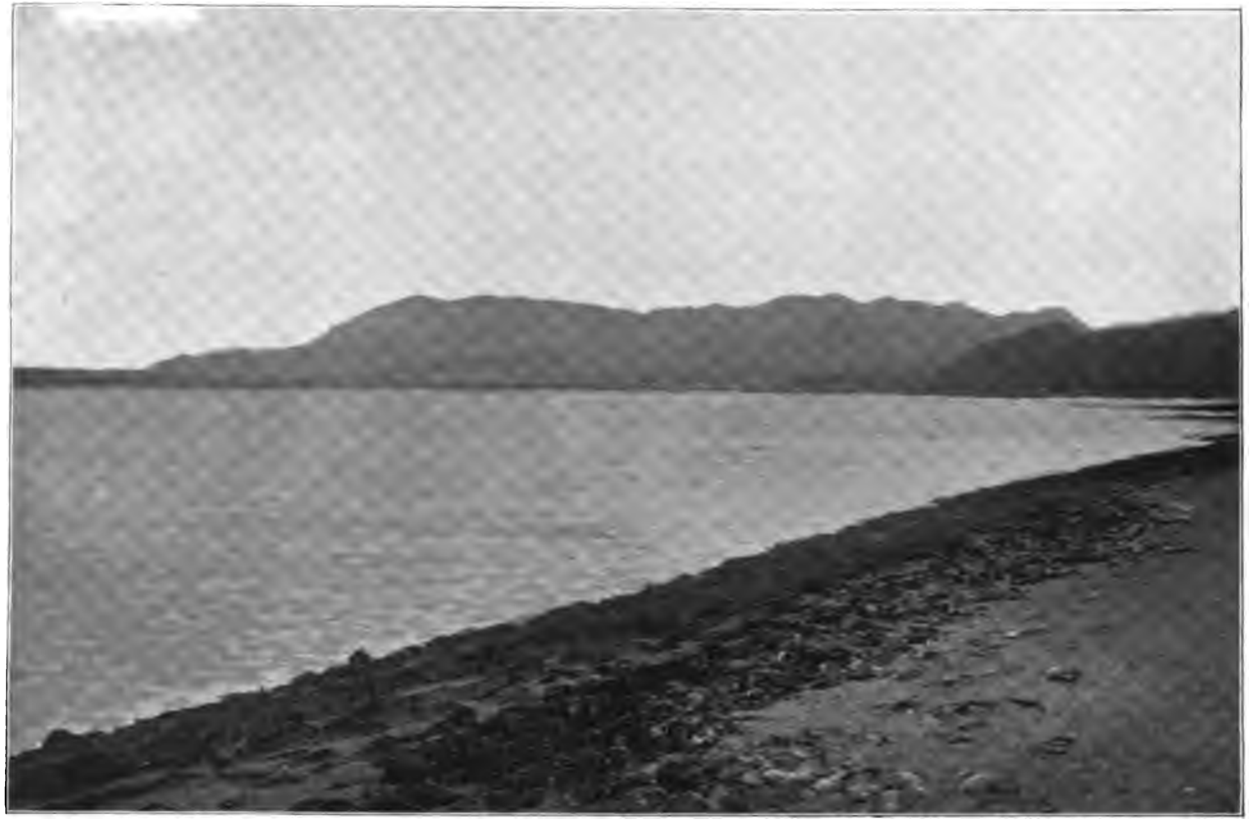


FIG. 4.—Section across dune ridges of Clatsop Beach.

The picturesque features of the coast are found not so much in its beaches as in its headlands. Of these, Tillamook Head, False Tillemook, and Meares Point are good examples. All are composed of igneous rocks, with cliffs against the surf, which break the continuity of the beach in each case for several miles. The northern end of Meares Point is shown in Pl. VI. A sheet of columnar basalt occurs near high-tide level, and enables the waves to cut out caverns of considerable dimensions. These in time enlarge and join, forming arches which when broken leave pillars and ledges, such as are seen on the right in the illustration, to mark the line of an earlier cliff.



NE AH KAH NIE MOUNTAIN, ETC., MOUTH OF NEHALEM RIVER.

The only headland of sedimentary rock seen on the coast by the writer is Otter Rock, which is composed of thin-bedded, yellowish Miocene sandstone. It is firmer than its neighbor, and sternly resists the dash of the waves, but is gradually giving way under their unceasing attack. One of its principal ledges, 40 feet above the water, is in places full of holes, made by the rock oyster at a time when the land stood 40 feet lower than now. Potholes are common on the surface, and from the north side a cave enters the rock, its roof having tumbled in and formed a great pit, known as the Caldron. It is 40 feet deep and of equal diameter. The débris at its bottom is swept away by the waves, and at low tide it can be entered from the beach.

HISTORICAL NOTES.

The earliest definite information concerning the geology of that portion of the country indicated as belonging to the Coast Range of Oregon is contained in the report of Prof. James D. Dana,[1] who accompanied the Wilkes exploring expedition. He collected a number of Miocene fossils from the shales and sandstones upon the banks of the Columbia River, near its mouth, and ascended the volcanic peak of Saddle Mountain. On the land tour from the Columbia River to San Francisco, Cal., between the head of the Willamette Valley and the broad plain of the Sacramento, he passed in some places along the eastern border of the Klamath Mountains, and at others the route lay within the eastern portion of that group.[2] He fully recognized the fact that they are composed chiefly of ancient granitic, hornblendic, and talcose rocks, besides some later sedimentary and igneous rocks.

Prof. J. S. Newberry[3] in 1855, as geologist to Lieut. R. S. Williamson's party of the Pacific Railroad Surveys, passed through the Willamette Valley and across the Siskiyou and other portions of the Klamath Mountains, following much the same route as that of Professor Dana a few years before. He writes as follows (p. 29):

> The continuity of the present Coast Mountains of California and Oregon can scarcely be doubted. The fossiliferous sandstones of Monterey, Santa Clara, San Francisco, Port Orford, Coos Bay, Astoria, and the Cowlitz are all of the same age. Though presenting marked local peculiarities, they have a common character, both in their lithological features and in their fossils, and are to be referred to a common period—certainly not older than the Miocene.
>
> As far north of San Francisco as Cape Mendocino the Coast Mountains have the same general northwest trend, and a more plausible supposition than that the Cascade formed the continuation of the Coast Mountains would be that the latter ranges terminate at Cape Mendocino and that the Coast Ranges of Oregon were a continuation of the Sierra Nevada. It is not necessary to suppose this, however, but it is

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[1] United States Exploring Expedition, 1838-1842, under command of Charles Wilkes, Vol. X, Chap. XVII, pp. 611-678.

[2] The mountains between the south fork of the Umpqua and the Sacramento Valley, according to Professor Dana, were the Umpqua Mountains and the Shasty Mountains. That portion of the Shasty Mountains near the boundary of Oregon and California Professor Dana called the Boundary Range. It is now generally known as the Siskiyou Mountain.

[3] Pacific Railroad Surveys, Vol. VI, Pt. II.

sufficient to consider the Coast Mountains of Oregon as the Coast Mountains of California deflected from the trend which they preserve below Cape Mendocino, and that the ranges of the coast and of the interior inosculate on either side of the parallel 42° in Calapooya, Umpqua, and Siskiyou Mountains.

The most important contribution of Professor Newberry to the geology of the Coast Range of Oregon is the announcement of the Miocene at Coos Bay, where it is said to contain valuable deposits of coal.

Prof. Henry D. Rogers,[1] upon a general geological map of the United States, in 1855 represented the Coast Range of Oregon, including the Klamath Mountains, as being made up chiefly of Miocene strata, inclosing 13 small isolated areas of volcanic rocks, distributed along the central portion from Saddle Mountain to the Umpqua.

In the same year (1855) Jules Marcou[2] published a map of the United States, upon which the Coast Range of Oregon, from the Columbia to the Klamath River, is represented as composed of Tertiary rocks, excepting about Coos Bay, where, on account of the coal, the Carboniferous is supposed to occur. Eruptive and metamorphic rocks are indicated from the upper portion of the Willamette Valley and the mountains on the coast near the Oregon and California line.

W. P. Blake[3] and Prof. J. S. Newberry, the next year, called attention to the fact that all the evidence thus far obtained indicated that the Coos Bay coal was of Tertiary and not of Carboniferous age.

In 1857 Prof. James Hall[4] and J. P. Lesley issued a geological map representing the Coast Range, from the Columbia River into California, as made up chiefly of a continuous mass of lava and igneous rocks, with Quaternary borders along the principal rivers of the coast. The Cascade Range is supposed to have a core of metamorphic rocks connecting it with the Sierra Nevada.

Prof. C. H. Hitchcock and W. P. Blake published three geological maps[5] of the United States; upon all of them the Coast Range of Oregon is represented as a continuation of the Sierra Nevada of California, and composed essentially of the same Eozoic and metamorphic rock. Upon the first two of these are areas of Cretaceous marked upon the Rogue and Illinois rivers, but these are omitted from the last edition.

About this time (1874) Professor Condon was appointed State geologist of Oregon and began a more continuous study of the geology of the Coast Range. In June, 1880, through Prof. E. D. Cope, the follow-

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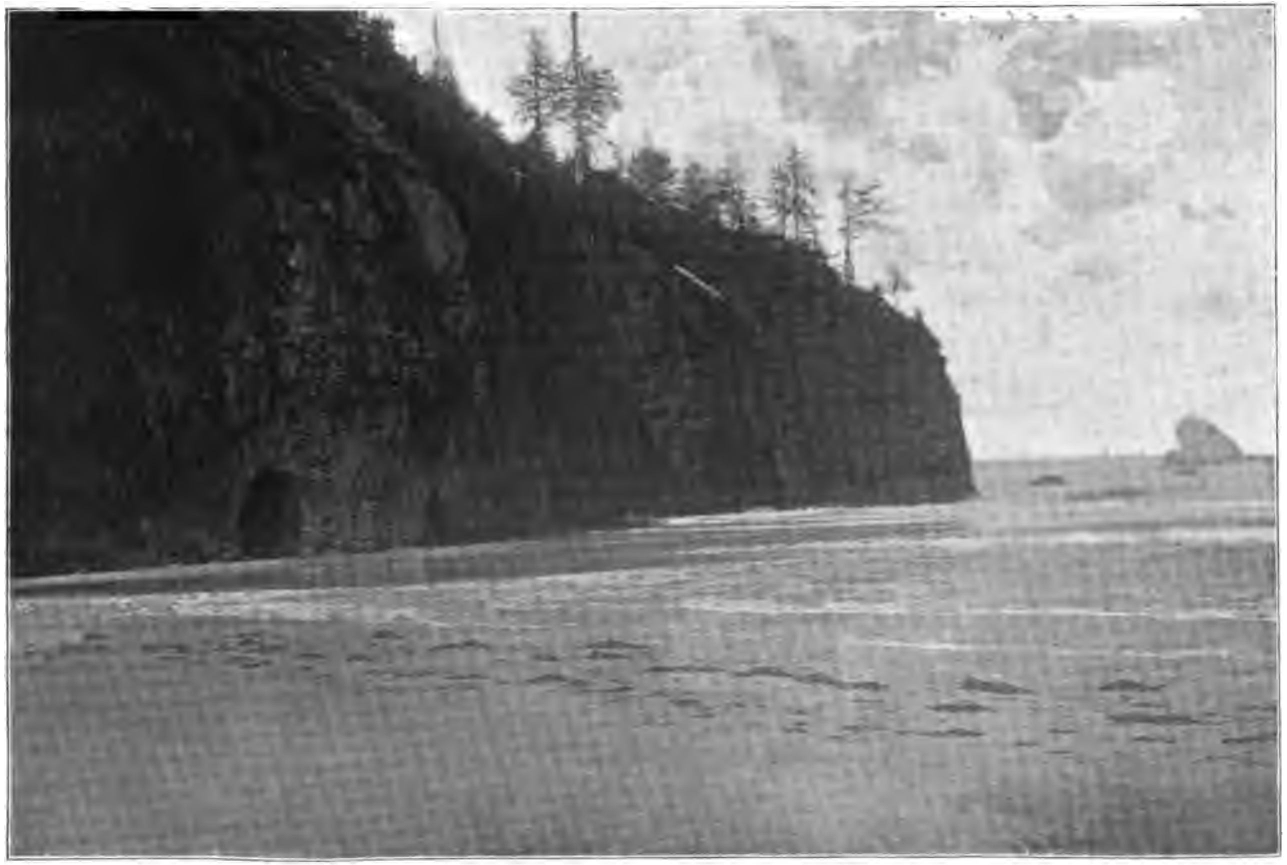
[1] Geological Map of the United States, Keith Johnson's Physical Atlas, p. 8.

[2] Carte géologique des États-Unis et des provinces anglaises de l'Amérique du Nord, Annales des mines, 5th ser., Vol. VII, p. 321, Pl. IX.

[3] American Journal of Science, November, 1856, Vol. XXII, 2d ser., p. 3. Blake also refers to Newberry as follows: Proceedings of the American Association for the Advancement of Science, Albany, 1856.

[4] Map illustrating the general geological features of the country west of the Mississippi, accompanying Report on the United States and Mexican Boundary Survey, by W. H. Emory.

[5] Geological map of the United States compiled for the Ninth Census, 1872. Geological map of the United States accompanying the report of R. W. Raymond, United States Commissioner of Mining Statistics, 1873. Geological map of the United States, in Walker's Statistical Atlas, 1874, Pls. XIII and XIV.



NORTH SIDE OF MEARES POINT.

ing note, entitled "Corrections of the geological maps of Oregon," was published:[1]

> In the existing geological maps of Oregon the Coast Range is represented as composed of Archean rocks. This is a serious error. Professor Newberry has already stated (U. S. Pacific R. R. Surveys, Vol. VI, Pt. II, p. 29) that the fossils of the range are of an age not older than the Miocene. The unpublished notes of Professor Condon, formerly State geologist, state that the backbone of the Coast Range consists of argillaceous shales, which contain invertebrate and vertebrate fossils, frequently in concretions. Some of the latter are Physoclystous fishes, with strongly ctenoid scales. To this formation Dr. Condon gives the name of Astoria shales. Above this is an extensive Tertiary deposit, rich in Mollusca, which is usually interrupted by the central elevations of the mountain axis. Professor Condon refers this to an upper Miocene age, under the name of the Solen beds. On the flanks of the mountains this is overlain by a Pliocene formation, containing some of the fossils of the Equus beds of central Oregon. This is both underlain and overlain by basalt and other volcanic products.

C. H. Hitchcock[2] published his large wall map of the United States in 1881. The geology of the Coast Range of Oregon was furnished by Professor Condon, who represented the distribution of the various formations in much greater detail than had been done previously. The mass of the range, according to the map, was supposed to be formed of Cretaceous sediments with large isolated tracts of volcanic rocks, stretching from the crest of the range toward the sea. Middle Tertiary strata are shown upon the flanks of the range, and perhaps also some older Tertiary. The two colors used to designate them can not certainly be distinguished upon the map examined by the writer.

In 1886, C. H. Hitchcock compiled for the American Institute of Mining Engineers a geological map of the United States, which, so far as the Coast Range of Oregon is concerned, follows the large map of 1881, and represents the backbone of that portion of the Coast Range as Cretaceous, with fringes of Miocene upon its flanks.

Dr. C. A. White announced the discovery by Professor Condon of strata containing characteristic Eocene fossils at Albany[3] in the Willamette Valley, and at Cape Arago,[4] and discussed the possible occurrence of Eocene strata near Astoria. In his correlation paper on the Cretaceous[5] is given a map showing the backbone of the Coast Range from the Columbia to near the latitude of Coos Bay to be of Cretaceous rocks, and in this respect the map agrees with the last edition of Hitchcock's map.

Dr. W. H. Dall[6] and G. D. Harris published a summary of the state of knowledge concerning the Neocene of the United States in 1891. The map showing the distribution of the Neocene formations, based largely upon information from Professor Condon, represents the Coast Range of Oregon as having a fringe of marine Neocene upon both flanks from the Columbia to the Siuslaw. The central portion of the range to the northward, and the whole of the range south of the Siuslaw, excepting at Coos Bay and Cape Blanco, are left uncolored, meaning thereby nothing more than the absence of the Neocene within the uncolored areas. They describe the Astoria group as consisting of Astoria shales and Astoria sandstone, and mention the Aturia bed at Astoria as well as the Miocene near Eugene City, in the Willamette Valley.

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[1] Am. Naturalist, June 1880, Vol. XIV, p. 457.

[2] In the pamphlet, by the same author, to accompany the map, it is stated, on page 28: "For this region (Oregon) we had a manuscript map colored for us by Professor Condon, and it was our lot to collect some additional information personally on the trip up the Columbia River and across the Blue Mountains. I understand that the distinction between the volcanic and the crystalline is not maintained in the Coast Range, and that some of the Cretaceous rocks in the southwest corner may be crystalline."

[3] Bull. U. S. Geol. Survey No. 18, 1885, pp. 7-9.

[4] Bull. U. S. Geol. Survey No. 51, 1889, pp. 29-32.

[5] Bull. U. S. Geol. Survey No. 82, 1891, p. 286.

[6] Bull. U. S. Geol. Survey No. 84.

Dr. G. F. Becker[1] and the writer,[2] in 1890, recognized the lower Cretaceous at Riddle, Oreg., and in later years the wider distribution of these beds[3] was recognized and discussed by the writer, who considered also the Eocene (Tejon) and described its areal extent, as well as its unconformity to the Shasta-Chico series.

The latest publication[4] by the writer touching upon the geology of that region contains a preliminary geological map of the Klamath Mountains, on which the general distribution of the Eocene southwest of Roseburg is represented. In a cover pocket of the same volume is included a reconnaissance map of the United States, showing the distribution of the geologic system as far as known, by W. J. McGee, in 1893. The outlines of the Miocene in the Willamette Valley and on the coast and of the Eocene at Corvallis and along the Umpqua north of Roseburg were drawn by the writer under the immediate direction of Professor Condon, who thus contributes the first definite knowledge concerning the general section of the Coast Range of Oregon.

GEOLOGICAL FORMATIONS.

PRE-CRETACEOUS.

Tupper Rock, near Bandon, at the mouth of the Coquille, is made up of blue schistose rocks, which, in places, contain numerous small brick-red grains.

The mass is composed chiefly of a blue mineral, which is strongly pleochroic, ranging from colorless through reddish violet to sky-blue, with the characteristic cleavage and low angle of extinction that belong to the blue hornblende, glaucophane. Besides the prismatic planes, the clinopinacoid is sometimes well developed. The glaucophane includes numerous small particles of a colorless mineral. Between the prismatic grains of glaucophane are clear ones, apparently of quartz, which are not readily detected on the broken surface of the rock, even with a lens. Occasionally the mass includes garnets, reddish on the weathered surface, but sometimes greenish on a fresh fracture. This is due apparently to the fact that near the garnet the hornblende is generally green, although some of it included in the garnet has the pleochroism of glaucophane. A short distance from the Tupper Rock is another, which is composed of a greenish, indefinite rock, whose composition and relations are in doubt. Among the ledges upon the beach, most of which are sandstones ranging from a compact form like basalt to fine conglomerate, there are outcrops of a greenish rock, which, from the fact that it contains numerous lath-shaped feldspars with much chlorite, evidently derived by alteration from some other ferro-magnesian silicate, is clearly of igneous origin. The sandstones are much disturbed, but in at least one place they appeared to dip beneath the glaucophane schist. The exposures here, upon the seaward side, are good, and it seems probable that by detailed study the origin of the glaucophane schist may be determined. The presence of both igneous and sedimentary rocks suggests that, as shown by F. Leslie Ransom,[1] for the glaucophane schist of Angel Island, it may be a product of contact metamorphism

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[1] Bull. Geol. Soc. America, Vol. II, pp. 203-205.

[2] Ibid., p. 207-208.

[3] Bull. Geol. Soc. America, Vol. IV, 1893, pp. 205-224; Bull. Geol. Soc. America, Vol. V, 1894, pp. 435-464.

[4] Fourteenth Ann. Rept. U. S. Geol. Survey, Pt. II, 1894, p. 414.

The age of the glaucophane schist and the associated sandstone near Bandon is not known, although it is supposed that they are older than the Cretaceous, from the fact that in the neighborhood of Roseburg glaucophane and other schistose with jaspery rocks appear to be unconformably overlain by the Cretaceous. In the same region limestones occur which are occasionally oolitic, and they contain traces of fossils. Mr. T. W. Stanton, to whom they were referred with a lot of Cretaceous fossils, reports that these have been examined by both Mr. Schuchert and himself without finding any definitely determinative fossils in them. He adds: "There are, however, some indications that they are Paleozoic rather than Mesozoic, in the presence of large cylindrical, crinoid columns and of two very imperfect columns that have a Paleozoic aspect, though the genera are not determinable."

Although these older stratified rocks form scarcely an appreciable portion of the Coast Range of Oregon—that is, the part north of the forty-third parallel—they rise in mass with many varieties and become a prominent feature of the Klamath Mountains. These older rocks have various forms of eruptives associated with them. Some of these are doubtless older than the Cretaceous, others may be younger, and the third class is certainly younger. The occurrence of some of the eruptives of this doubtful middle period in several rocks of the range suggests that there may be an irregular ridge of older rocks concealed beneath the newer ones, which form the mass of the range. At one time, as mentioned in the "Historical notes," it was supposed that these ancient rocks of the Sierra Nevada entering Oregon turn northerly along the coast and form the greater portion of the Coast Range. But that opinion must be abandoned, as it is quite improbable that pre-Cretaceous sedimentary rocks form any considerable portion of the Coast Range in Oregon north of the Coquille. So far as evidence is known, it indicates that they do not enter into the composition of this part of the range.

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[1] Bull. Univ. of California, Department of Geology, Vol. I, Geology of Angel Island, pp. 193-240.

CRETACEOUS.

On a number of geological maps, as already indicated, the Coast Range of Oregon was marked as being composed chiefly of Cretaceous rocks. This is far from being the fact, for no certain Cretaceous rocks are known in the range, and yet it is probable that they do occur where it joins the Klamath Mountains. South of Roseburg a short distance, along Myrtle Creek, are Cretaceous conglomerate sandstones and shales, resting upon the older rocks, from which they were derived. That these sedimentary rocks belong to the Cretaceous is clearly indicated by the form of Aucella and other fossils which they contain. In the Coast Range, at several points along the new stage road between Myrtle Point and Remote, there are similar rocks, and it is probable that they belong to the Cretaceous, although no fossils have yet been found in them. They unconformably underlie the Eocene sandstones which form the mass of the Coast Range where it abuts against the Klamath Mountains, and are not seen as far north as the Middle Fork of the Coquille.

EOCENE.

One of the most important contributions to the areal geology of northwestern Oregon made by this reconnaissance is the recognition of a large tract of Eocene forming the mass of the Coast Range from near the Columbia to the Coquille. While it is possible that the Miocene strata may in places, especially toward the northern end, form a considerable portion of the range, they are of far less importance, so far as bulk and area of exposure are concerned, than the Eocene strata.

The rocks of Eocene age belong in part to each of the two groups, igneous and sedimentary rocks. Those of the first group, although much altered, are chiefly basalt and associated tuffaceous materials. To the second group belong the shales and sandstones. The rocks of these three geological divisions are not clearly distinct, being more or less interstratified, but in general the oldest Eocene strata are those composed of volcanic material, and they are closely associated with the lavas to which they belong. Next above them comes a great mass of shales, containing here and there much material of igneous origin, and in the upper part of the series massive beds of sandstone predominate. For convenience, these three groups will be considered separately.

IGNEOUS SEDIMENTS.

These are best exposed upon the Nehalem River, in Klatsop County, about 2½ miles below the mouth of Humbug Creek. The slopes of the canyon through which the river runs, from a few miles below Mishawaka for about 20 miles toward its mouth, are formed largely of basic igneous rocks. They occasionally form rapids in the stream.

Associated with these eruptives are tuffaceous sandstones, which occasionally contain conglomeratic portions with small, often angular, pebbles. The material appears as if originally ejected from a volcano rather than derived by erosion from the rocks with which it is associated, and would therefore be essentially contemporaneous with the volcanic eruptions. It contains a few fossils, among which Dr. Dall recognized Tayloriana Gabb; *Modiola multiradiata* Gabb; *Modiolaria* n. sp., besides Ostrea (?), Callista, and Dentalium, and regards them as Eocene (?).

Near Felix Roy's, on the Nehalem River, about 5 miles east of the Nehalem post-office, Mr. Anderson observed much conglomerate of eruptive material and a heavy bed of tuff, from which were collected, according to Dr. Dall, Ostrea, *Modiola ornata* Gabb, *Modiola cylindrica* Gabb, *Septifer dichotomus* Gabb, and *Turritella uvasana* Conr., which he regards as Eocene.

Igneous rocks which closely resemble those seen on the Nehalem occur on the north bank of the Columbia opposite Astoria and near Ilwaco. At Meglers Landing, in that region, the tuff contains fragments of Ostrea, Dentalium, and casts of a gasteropod, but nothing characteristic was found. These beds, however, appear to underlie unconformably the Aturia beds which occur farther eastward.

From Tillamook there are two stage roads across the mountain to the Willamette Valley, one by way of Wilson River and the other by the Trask. Both streams cut deep canyons down the western slope and expose a great mass of igneous rocks, which form the greater part of the range. They reach to the foot of the range, only 5 miles from Tillamook Bay. At the mouth of the Wilson River Canyon the rock is chiefly conglomerate, of waterworn volcanic material like that against which it rests. Farther up the canyon, near the mouth of Fall Creek and at several other points, shales and sandstones were noted among larger masses of volcanic rocks. About 22 miles from Tillamook, a short distance below Smith's, on the Wilson River toll road, and also near by on the river, the rocks are found to be fossiliferous, containing *Turritella uvasana*, as well as Ostrea, Pecten, Nucula, and Hipponyx, and other forms not definitely determinable. There appears to be no doubt as to their Eocene age.

Proceeding southward, the next locality of volcanic sediments noted was at Vineyard Hill, 4 miles north of Corvallis, where a more or less amygdaloidal eruptive like that of the Nehalem occurs, and in the sediments associated with it are found a few fossils, discovered by the enthusiastic local geologist Mr. John Ray. Not enough fossils were gathered to fully establish the age of these beds, but in the shales immediately to the eastward, about Howes, characteristic fossils, as

Modiola ornata Gabb, with others, have been found by Mr. Ray, and there can be little, if any, doubt concerning the age of the volcanic sediments of Vineyard Hill. They extend westward, cropping out here and there, possibly as far as Blodgetts Valley, where Mr. Anderson collected fragments of *Aturia angustata*, Ostrea, Pecten, Cardium, and Leda, which Dr. Dall referred without doubt to the Oligocene. They are confined to the eastern portion of the range, and in the section afforded by Marys River do not extend to the summit. Similar strata occur also at Monroe, 18 miles south of Corvallis, but they are not fossiliferous.

The same general sort of basic igneous rocks occur about Roseburg and at several points on the western side of the Coast Range on the road to Coos Bay, but so far as yet known the only sediments of such material in the Coos Bay region occur on the east coast opposite North Bend. The tuffaceous sandstone dips 40° to the westward, and is overlain by shales and sandstones having a gentler dip but rich in Eocene fossils.

The age of the eruptives associated with the Eocene beds composed of the same material is in many cases not definitely known. While some of them are essentially contemporaneous, it is possible that others may be older, but of this the evidence is not yet conclusive.

SHALES.

Arago beds.—On the Washington shore of the Columbia near Ilwaco is a prominent hill of dark-gray shales capped by a bed of Pleistocene sand. The shales look somewhat like those of Astoria, but their strike is N. 39° E., dipping 35° to the northwest, and so far as their position indicates, there is no continuity with those of Astoria. The fossils determined by Dall in this locality are Calliston sp., Dentalium n. sp., and Modiola like tulipa Lam, which he with doubt referred to the Eocene.

Some of the best exposures of the Eocene shales observed are upon Rock Creek from 6 to 10 miles above Vernonia, in Columbia County. At several points there are cliffs of shale containing large concretions and thin, sandy layers. The latter under microscopic examination proves to be composed almost wholly of material derived either directly from volcanoes or by erosion from igneous rocks. The shales weather gray, but on a fresh fracture are dark, containing much vegetal matter. They strike N. 82° E., and dip very gently to the southeast, away from the older rocks in the region of the Rock Creek mines. From the fossils collected at this locality Dr. Dall reports Nucula sp., *Liocardium linteum* Conr., *Tellina hoffmaniana* Gabb, *Cylichna cf. costata* Gabb, *Mocoma* n. sp. (?), and *Turbo* (?) n. sp., from one bluff, while *Yoldia cf. montereyensis* Dall, *Cassadaria* (=*Phalium*) *turberculata* Gabb, and a number of other forms, most of which are known, come from another bluff. The former are referred, apparently without doubt, to the Eocene, but the latter are referred to the Eocene or Oligocene. In the field these shales were considered to be the lower part of the series exposed on the Nehalem at Wilsons Bluff, from 1 to 3 miles above Vernonia, where a number of Oligocene fossils were found.

One of the most interesting Eocene exposures occurs farther down the Nehalem, in Clatsop County, at the fording nearly midway between Jewell and Mishawaka. At this point about 60 feet of shales are exposed, with some arenaceous beds of igneous material. The shales have rather large concretionary masses, and strike N. 22° W., with a dip of 15° SW. In the shales and concretions numerous fossils are found, of which Dr. Dall reports the following: Crab, coral, *Dentalium* n. sp., *Yoldia* n. sp., *Thracia* n. sp., *Verticordia* n. sp., *Cardium breweri* Gabb (?), *Liocardium linteum* Conr., *Lyonsia* n. sp., *Bela* n. sp., *Fulgur* (?) sp., *Heteroterma trochoidea* Gabb (?), *Rimella canalifera* Gabb, *Urosyca caudata* Gabb, *Pyrula tricostata* Lam., *Ampullina* sp., *Scaphander* n. sp., and *Aturia angustata* Conr.

Notwithstanding the presence of Aturia, which is a characteristic Oligocene form, Dr. Dall refers these fossils to the Eocene. The Aturia found here is the largest specimen seen during the reconnaissance, much larger than any of those collected in the Oligocene, and it is not improbable that Aturia reached its greatest development before the close of the Eocene.

South of Columbia County, on the east side of the Coast Range, these shales were not seen in Washington, Yamhill, or Polk counties. The first outcrop noted is 5 miles north of Corvallis, near Benson's and Howe's, where, at localities pointed out by Mr. John Ray, *Modiola ornata* Gabb, *Solen parallelus* (?), *Nucula truncata* Gabb, *Tellina remondi* Gabb, and other forms were collected.

Near Corvallis Mr. John Ray has collected numerous fossils and gathered much information concerning their distribution. His collection is confined to Benton County, and is deposited in the State Agricultural College at Corvallis. Under his guidance a number of Eocene forms were obtained, not only from the shales near Benson's and Howe's, east of Vineyard Hill, but also from the more sandy layers near Scott's, Cooper's, and Newton's, a few miles southwest of Corvallis. The strike of the strata of that region is approximately north and south and the dip easterly. The same formation continues to the southwest, and is full of fossils. Near Rogers's, in sec. 27, T. 13 S., R. 6 W., where the strike is nearly east and west and the dip about 20° to the northward. Venericardia occurs, with an abundance of other fossils, in a ledge of sandstone, of which a thickness of about 30 feet is exposed.

Four miles directly east of Rogers's, at the foot of Coon Hill, on Foster's upper place, above a shaft sunk in prospecting for coal, is a soft fossiliferous sandstone that strikes north and south and dips westerly. The specimens of *Venericardia planicosta* Conr. and casts of Modiola found here show that the rocks belong to the Eocene. The discordance in position at the last two localities may be due to the intrusion of igneous rocks, by which they are separated.

A few miles farther southward, near Monroe, the Eocene beds continue to be fossiliferous, and in the John Ray collection from this locality Mr. Anderson determined *Cardita planicosta*, *Galerus excentricus*, *Modiola ornata*, and other forms. In Long Tom Creek, at Monroe's, a low arch of tuffaceous sandstone is exposed, and appears to run under the strata of the hills a short distance to the westward. The sandstone in the quarry by the road close to Monroe's is sparsely fossiliferous, and according to Dall the forms are Miocene. They dip gently eastward, and the Eocene beds must lie some distance to the west.

The distribution of the Eocene strata from Corvallis to Monroe's shows that they extend directly south parallel with Long Tom Creek, and this opinion is confirmed by the appearance of *Venericardia planicosta* and other Eocene forms near Comstock, on the railroad between Drain's and Cottage Grove. The dark fossiliferous shales near Comstock have been prospected for coal, but thus far without profit. The prominent hill northwest of the station is of sandstone overlying the shales, and affords an excellent view to the westward. Fossils have not been found in the sandstone, and its relation to the underlying shales is not certainly known. Its topographic relations indicate that it is the same sandstone which forms the prominent escarpment of the range from Tyee Mountain to Camas. Fossils have not been found in the massive sandstone along this bold front, but at a number of points they have been collected in the underlying beds, chiefly shales, as, for example, in Douglas County, at Cleveland, and near Callahan's, in the upper portion of the French settlement (secs. 9 and 15, T. 27 S., R. 7 W.), and in Camas. All of these are of Eocene age, and it seems probable, as will be noted later, that the sandstone itself is Eocene.

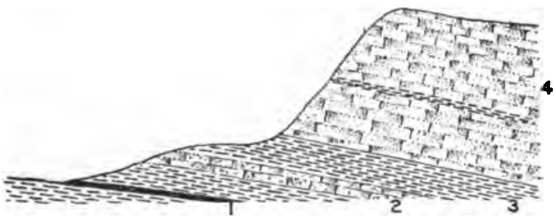


FIG. 5.—Section from Callahan's westward to crest of Coast Range. 1, Coal; 2, Fossiliferous sandstone; 3, Shale; 4, Sandstone.

Opposite Callahan's a trail ascends this rugged front, and the section, fig. 5, illustrates the relations of the exposed strata.

At Callahan's is coal (1) and the fossiliferous beds (2 and 3), which are clearly Eocene. They are chiefly shale, but contain occasionally sandstones and rarely calcareous nodules of considerable lateral extent. At one place they have been burned for lime. The basal portion of the mountain is generally covered by slides of soft sandstone from above, but the only rocks seen in place were shales. The upper half of the mountain is sandstone, having a thickness of about 1,000 feet. Its distribution will be considered after the description of the underlying shales has been completed. There is no reason to suspect that the heavy sandstone at the top of the series overlies the shales unconformably in this section, but at several other localities such discordance is indicated. However, in these cases the underlying beds may not be of Eocene age. The difference in altitude between Callahan's and the crest is nearly 2,000 feet. The dip of the strata is about 8° to the northwest, and the whole thickness of strata exposed above Callahan's is probably not less than 3,500 feet.

East of the Coast Range, between the Callapooia and Rogue River mountains, in the irregular valley drained by the forks of the Umpqua, the Eocene shales, with their interbedded sandstones, have a wide distribution, and fossils occur in many places. They are especially abundant about 20 miles northeast of Roseburg, near the mouth of Little River, where the characteristic *Venericardia planicosta* occurs, and the strata contain some beds of coal.

On the coast of Oregon outcrops of Eocene strata are not known north of Cape Arago, but at that point, as long since made known through the observations of Professor Condon, highly fossiliferous sandstones and shales are well exposed. They strike about N. 10° W. and dip 60° to 70° to the northeast. These beds are largely shales, but numerous sandstones occur, most of which are thin, although some are heavy enough to form prominent bluffs and points projecting to the water's edge. East of Cape Arago these highly inclined Eocene strata are exposed continuously along the beach for several miles, and it is evident that their thickness is very great. These fossiliferous strata are well exposed along the road immediately north of Marshfield, and also at Jordan Point, on the eastern side of the bay, where they rest upon a mass of older tuffaceous material. Judging from their position, one would say that they include the valuable coal beds of that region, but as the fossils found in immediate connection with the coal are not characteristic, the evidence is not yet conclusive.

Among the fossils found in the beds at Cape Arago, Dr. Dall reports the following:

Modiola ornata Gabb.
Venericardia planicosta Lam.
Pectunculus veatchii Gabb.
Turritella uvasana Conr.
Species of Thracia, Diplodonta, Callista, and Leda.

One mile east of the cape, in the same series, were found:

Callista n. sp.
Mactra darienensis Dall
Chione sp. n.
Cyclina n. sp.
Modiola ornata Gabb.

And at Jordan Point:

Turritella uvasana Conr.
Ampullina sp.
Lunatia eminula Conr.
Pleurotoma n. sp.
Dentalium (2) n. sp.
Tellina remondi Gabb.
Yoldia, Leda, Solen, Tellina, and Callista.

On account of the fact that this series of beds is so well exposed at Cape Arago and contains characteristic fossils relegating them definitely to a position high up in the Eocene, they are called the Arago beds.

About a mile east of Cape Arago the Arago beds contain a small layer of coal and thin seams or lenses of limestone; some beds of sandstone also occur here and there in the shales. This series of highly inclined strata extends eastward from the cape to the vicinity of Coos Head, where it is in all probability overlain unconformably by the massive Miocene sandstones which dip gently (18°) to the northeast. In the season of low tides it is said that a person can easily follow the beach from South Slough to the cape, but at the time the writer was there the water, even at low tide, was so high that about a mile of the beach near Coos Head was impassable. The contact of the Eocene and Miocene occurs along that portion of the beach. It is doubtless well exposed in the bluff, and the discordant positions of the strata at the points where they are seen nearest together strongly suggest a conspicuous unconformity between them.

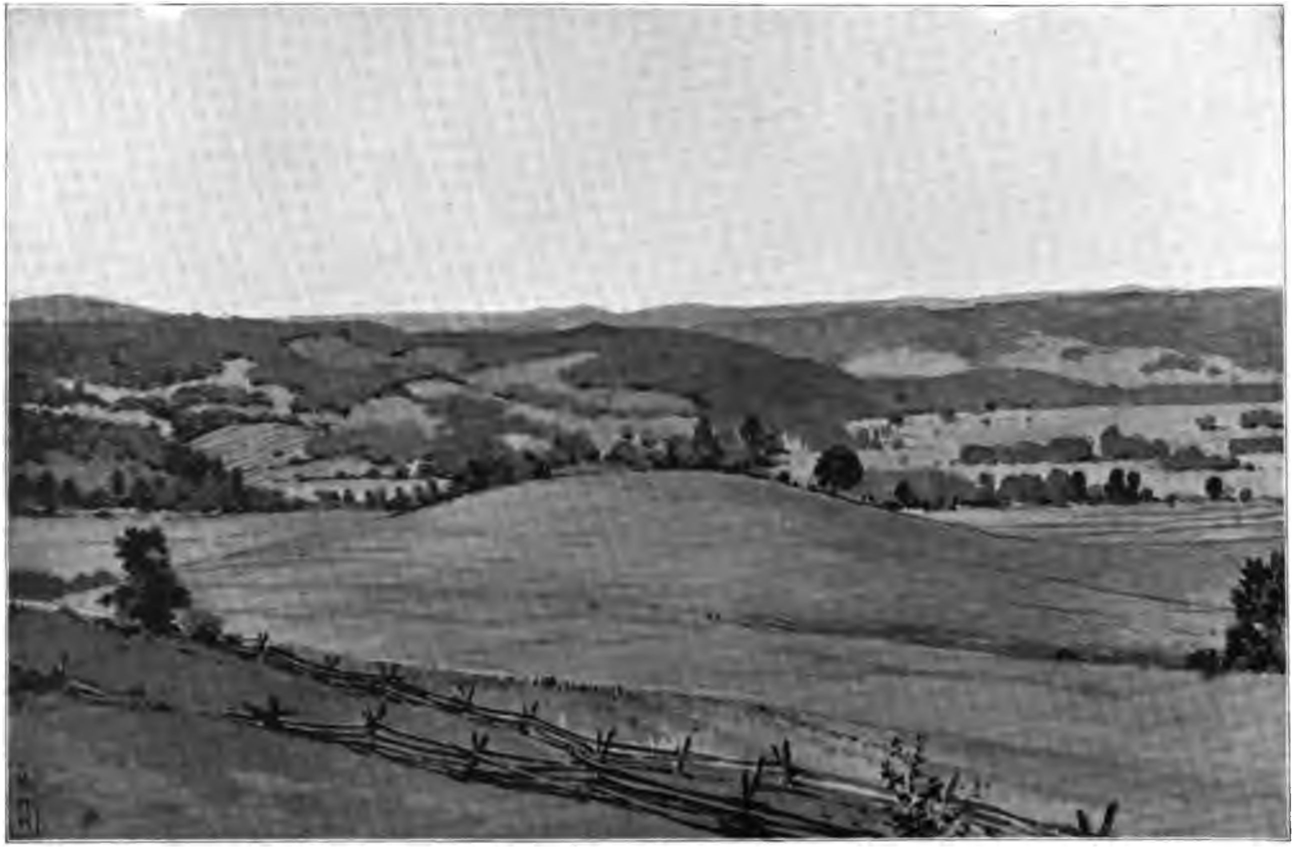
To the southward from the cape the Arago beds extend along the coast to near the mouth of the Coquille, where the older crystalline rocks appear. *Turritella uvasana* Conr. was found in the shales of Five-Mile Grade (sec. 3, T. 27 S., R. 14 W.), and in a bluff by the road near Lampers Landing on the Coquille numerous characteristic Eocene forms occur in the sandstone and shales. In the valley of the Coquille, after leaving the older crystalline rocks at Bandon, sandstones outcrop with occasional shales much of the way to Myrtle Point, where a larger outcrop of dark shales with calcareous but nonfossiliferous concretions occur. Similar shales occur farther northward along the old stage road from Fairview to beyond Dora, a distance of about 11 miles, and near Abinethy's they contain *Trochita filosa* Gabb and fragment of bivalves referred by Dall with doubt to the Eocene. They dip to the northeastward at an angle of 25°, and appear to plunge beneath the great irregular synclinal mass of sandstone which forms in this latitude the main body of the Coast Range.

SANDSTONES.

The sandstone which prevails in the upper portion of the series of beds belonging to the Eocene is best exposed in the prominent mountain escarpment 12 miles directly west of Roseburg. Pl. VII shows the escarpment in the distance.

At this point, as shown in fig. 4, the sandstone near its middle has a thin parting of shale which contains vegetal fragments.

It is the same sandstone which forms the crest from Tyee Mountain to Camas and apparently passes through the divide (Camas Mountain) between Olalla Creek and the Middle Fork of the Coquille to Table Mountain near Nichols Station. At Table Mountain nearly 2,000 feet of approximately horizontal sandstone are exposed, and near the summit it contains fossils which occur in the Eocene. The same is true of



VIEW WEST FROM ROSEBURG.

the east slope of Camas Mountain, where in sandstone overlying the shale a few other apparently Eocene forms were found. The fossils in this sandstone, however, are not so characteristically Eocene as are those of the shale at Bushnell's mine and near Dickinson's Rock, in the the same neighborhood.

From the bold front stretching from Tyee Mountain to Camas the sandstone extends westward toward the ocean and forms the mass of the Coast Range. It is well exposed along the old stage road from Roseburg to Coos Bay, in the canyon cut by the East Fork of the Coquille, and on the new stage road in the canyon of the Middle Fork of the same river, for nearly 20 miles west of Camas Prairie. It contains fossils 2 miles northwest of Remote, at Elbow Hill, and opposite the mouth of Boulder Creek. Fragments of Tapes, Natica, Ostrea, Tellina, Solen, Venus, Mactra, and Arca are reported by Dall, but no positive determination of species or of age is given. The dip of the beds is such as to indicate that the mountain is in part at least a syncline. This is true also on the old stage road, but not so evident, for the western limb has a very gentle inclination to the eastward, and near the middle of the mass the strata are occasionally disturbed as if faulted. The strike varies greatly, and is evidently much influenced by the proximity to the old rocks of the Klamath Mountains, which begin with the drainage of Rogue River.

The relation of this sandstone to the underlying Eocene shales is not yet definitely known. While at some points there appears to be no reason to suspect that they are discordant, at others, as for example on the Umpqua, at the base of Tyee Mountain, and near the Nineteen Mile House on the old stage road from Roseburg to Coos Bay, there is a decided unconformity suggested. It is not known, however, that the underlying strata are in all cases of the same age.

To the northward the extent of the sandstone beyond Comstock is not known. It appears to grow thinner in that direction, and possibly passes locally into shales. In the Upper Nehalem coal field, however, there is much sandstone which may belong in the upper part of this series, although it is by no means even more than probable that it corresponds closely to the heavy mass in Douglas County. In the collections from near the coal beds of Pebble Creek, *Nucula truncata* Gabb, *Tellina hoffmaniana* Gabb (?), *Tellina longa* Gabb, *Mactra ashburneri* Gabb (?), *Neverita globosa* Gabb, and *Rimella simplex* Gabb were recognized by Dall and referred to the Eocene.

Much of the Eocene sediment was derived from the Klamath Mountains and their northeast extension toward the Blue Mountains. Near their source the sediments are much thicker and coarser. Conglomerates are not uncommon in the Eocene of Douglas County, but they are rare in Columbia County. Sandstones form prominent ridges throughout the areas of Eocene west of Roseburg and about Oakland, but farther northward they make but little impression on the topography.

OLIGOCENE.

The next system of strata younger than the Eocene recognized by Dall on the Pacific Coast is the Oligocene, which includes the Astoria beds on the Oregon shore of the Columbia near its mouth.

Prof. James D. Dana,[1] in 1841, examined the shales and sandstone on the Columbia about its mouth and described them, noting also the interesting sandstone dikes which they contained. He referred to the dikes as evidence that the shales were overlain by sandstone such as that filling the fissures.

Prof. Thomas Condon collected numerous fossils at Astoria and other points in the Coast Range, and named the argillaceous shales—which he considered as forming the backbone of the range—the Astoria shales.[2]

Dr. C. A. White[3] considered part of the fossils collected about Astoria by Dana and Townsend and described by Conrad[4] as Eocene, and thus the Astoria shale of Condon was shown to embrace beds of different ages.

Dr. W. H. Dall visited Oregon in 1890, and in describing his results used the term Aturia bed for the lower or Eocene portion of the series, characterized chiefly by the presence of *Aturia ziczac*. Recognizing both the sandstone and shales referred to by Dana, he remarks:[5]

> The impression produced on the mind by an inspection of these rocks, though without the opportunity to examine any large district with care, was that the shales and sandstones form a part of a single series varying in character of its beds or layers according to fluctuations in the sedimentation, the shales being more argillaceous, the sandstones more arenaceous, neither possessing an exclusive character, the fossils appearing to be the same Miocene species in both, with a tendency to form concretions around them in the shale and to be represented by casts in the sandstones. The name of Astoria group is proposed to include them both, but not the subjacent Eocene Aturia bed.
>
> At Smiths Point, west of the town, the shales are very low, the vertical face not exceeding 15 feet. They dip about 16° in a southeasterly direction, and are composed of thin layers of chiefly bluish gray shale with numerous fractures lined with peroxide of iron, which develop more numerously as the surface dries, while the iron causes the face to weather of a brownish color. The layers mostly contain a little sand; some do not show any. The fluctuations appear to succeed each other with a certain regularity. Here and there a little gravel is mixed in one of the layers, and in these gravelly layers are also small fragments of bivalve shells, the most perfect and numerous being those of a small concentrically undulated Pecten of the section Pseudamusium; Acila and Waldheimia were also observed.
>
> In the upper layers of the shale the clayey parts occasionally form lines of concretions along a bedding plane, partly fossiliferous. The most common fossil here is a species of Macoma.
>
> Above the shales at this point is a bed of 8 to 20 feet in thickness of a yellowish clayey sand with irregular, mostly rounded fragments of a harder sandstone, macu-

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[1] Wilkes Exploring Expedition, Vol. X, Geology, by Dana, p. 653.

[2] American Naturalist, June, 1880, Vol. XIV, p. 457.

[3] Bull. U. S. Geol. Survey No. 51. pp. 31-32.

[4] Wilkes Exploring Expedition, Vol. X, pp. 722-729, and Am. Jour. Sci., 2d series, Vol. V, pp. 432-433.

[5] Bull. U. S. Geol. Survey No. 84, p. 224.

lated with peroxide of iron with a few traces of marine fossils, and more or less gravel not regularly bedded, and penetrating into fissures in the shaly rock below in the form of dikes.

The Aturia bed is characterized by the presence of the form whose name it bears. It was once exposed on the water's edge at Astoria, but is no longer accessible on account of improvements of the water front. On the opposite shore of the river, three-fourths of a mile above the Knappton sawmill, the shales in which it occurs are well exposed. Aturia has been found in the shales and sandstones at a number of points south of the Columbia on both sides of the Coast Range; on the east at the fording of the Nehalem above Mishawaka, in Clatsop County, and near Blodgett in Benton County, and on the west at the old jetty quarry on Tillamook Bay.

Other fossils, relegated by Dr. Dall to the Oligocene and belonging essentially to the same horizon as the Aturia, have been found in sandstones and shales on the Scappoose, Clatskanie, and Nehalem in Columbia County, at Short Beach in Clatsop County, and northeast of Dallas in Polk County. Beginning at the north and proceeding southward, the localities will be noted first on the eastern side of the Coast Range and then on the western.

Near the sawmill at Knappton are shales with many calcareous nodules, but the only fossils found in them were fragments of crabs. Near by are exposures of old rocks upon which the shales at a number of points along the north shore of the Columbia appear to rest with a decided unconformity. At this point the older rocks strike N. 26° E., and dip 45° to 48° SE., and contain veins of calcite and possibly of quartz. Continuing along the shore, the shales appear again with approximately the same position as that noted for the older rocks. Concretions are abundant and fossiliferous, furnishing, according to Dall, the following species: *Aturia angustata* Conr., *Dolium petrosum*, *Dentalium* sp., Yoldia indet., Anatina fragment, Amusium fragment, Crabs 2 sp.

How far the Aturia-bearing shales extend eastward was not determined, although shales were exposed some distance toward Grays Bay, beyond where the fossils were obtained. There must be at least 500 feet of shales exposed at this point.

On the road to Mist, 2 miles southwest of Clatskanie, at an elevation of about 150 feet above the river, there is a mass of soft sandstone containing a very fossiliferous nodule 2 feet thick. *Dolium petrosum* Conr., *Neverita globosa* Gabb, *Nucula truncata* Gabb, Callista, and Diplodonta are among the forms recognized by Dall. The position of the strata is not readily determined with certainty, but there are indications that they dip northerly. If so it would be expected that the soft sandstone containing the nodule would be younger than the shaly sandstones on the same road at an elevation of 700 feet. This is not true, however, for the fossils the latter contain are Pliocene.

Several years ago, through Mr. Will Q. Brown, a small collection of fossils was obtained from Westport on the Columbia. Dr. Dall reported (letter December, 14, 1892) that they belong "probably to the horizon of the Aturia bed which immediately underlies the Miocene Astoria shales."

On the North Fork of the Scappoose, about 5 miles northwest of the station of the same name at the mouth of Fall Creek, the soft, gray, fine sandstone is cut to small pieces by joints, yet some of the fossils are well preserved, and among them Dr. Dall identified *Nucula truncata* Gabb, *Fusoficula tricarinata* Lam., and *Nererita aëtites* Conr. (?), besides a number of other forms. The position of the beds is strike N. 40° W., dip 19° to the southwest.

About 20 miles northwest of Scappoose, at Pittsburg, on the Nehalem, is one of the finest exposures of Oligocene strata observed in Columbia County. A view of the bluff is given in Pl. VIII. The upper soft gray sandstone is very fossiliferous in places, and about 30 feet in thickness. Below are 20 feet of dark shales which weather gray. The whole series dips northeast at an angle of about 5°. Some of the layers of sand are indurated so as to make slabs, thickly set with perfectly preserved fossils. Generally the sandstone is soft and the numerous fossils it contains are so fragile as to be preserved with great difficulty. Solen is abundant in one or more of the layers, and recalls the name Solen beds, proposed by Condon[1] for the sandstones overlying the Astoria shales of the Coast Range generally. Among the grains of sand in the sandstone are found particles of pumice, probably indicating contemporaneous volcanic activity.

The fossils identified by Dr. Dall from this locality are *Nucula truncata*, *Solen parallelus* Gabb, *Mya præcisa* Gld., *Nererita saxea* (?) Conr., besides Leda, Dentalium, Diplodonta, Macoma, Tellina, Callista, Mactra, Lunatia, Cylichna, and Molophorus, of which most of the species are new.

The fossils of the shales are generally contained in concretions, some of which are large. Farther up the Nehalem, 1 mile beyond Vernonia, the same dark shales, weathering gray, occur as at Pittsburg. Thirty feet of them are exposed by the stream, and they are nearly horizontal. When wet and dried in the sun they fall to pieces, so that erosion is rapid. Fossils are not uncommon. All those collected here were found also at Pittsburg excepting Pentacrinus and Periptoma.

At Wilsons Bluff on the river, 3 miles above Vernonia, gray shales appear, with concretions, some of which are 10 feet in diameter, parallel to the bedding and 2 feet perpendicular to it. Most of the concretions are small, and, as already noted at many other places, contain the carapace or legs of crabs. The strata dip gently to the eastward, and it is evident that the shales above Vernonia are older than those at Pittsburg. Although the whole section seen on the Nehalem from Wilsons Bluff to Pittsburg is at least 10 miles in length, it is not directly across

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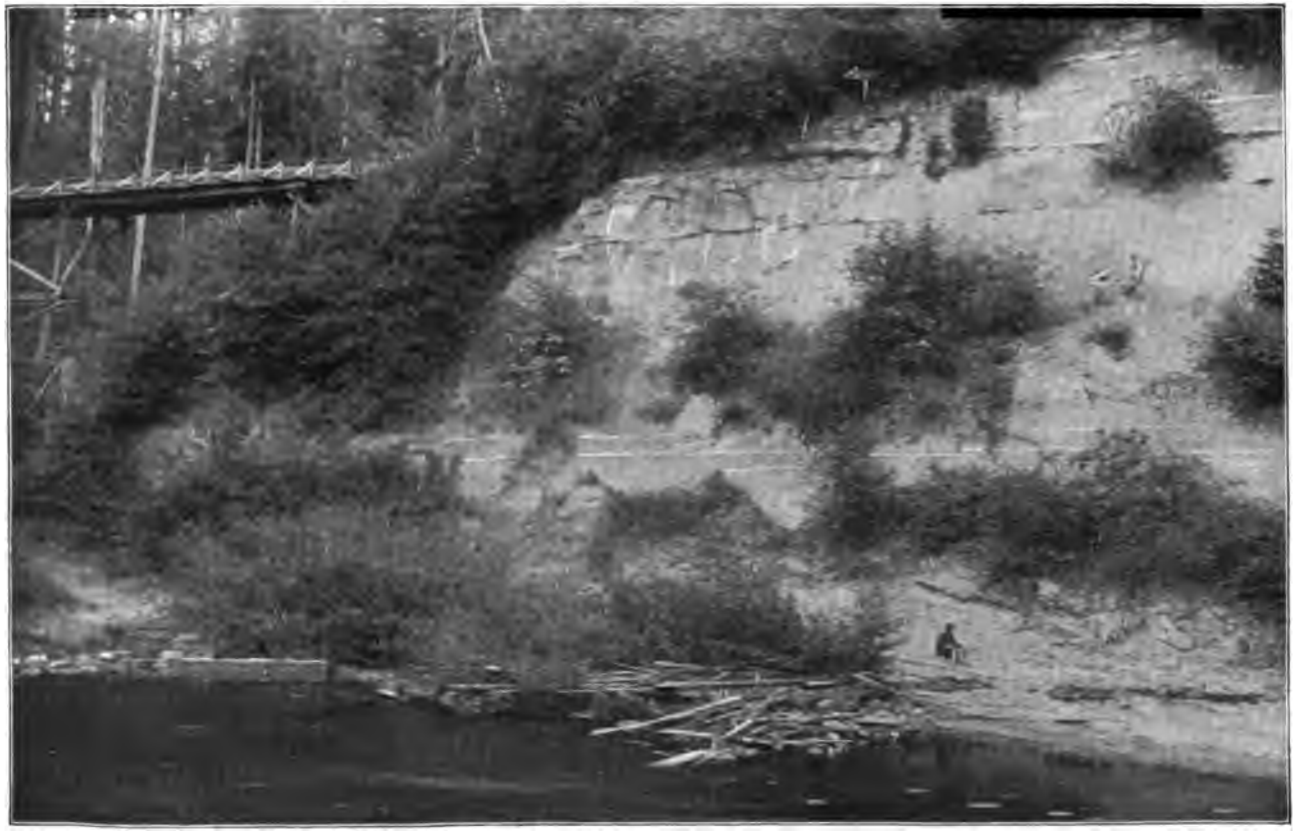
[1] Am. Naturalist, June, 1890, Vol. XIV, p. 457.



PITTSBURG BLUFFS.

the strike and does not expose more than a few hundred feet of shales and overlying sandstone.

The fossils found at Wilsons Bluff are *Dolium petrosum* Conr., *Nucula truncata* Gabb, *Yoldia impressa* Conr., *Pseudomusium peckhami* Gabb, with Dentalium, Scaphander, Cylichna, Leda, and Tellina. The party did not follow the Nehalem farther up than Wilsons Bluff, but the section must be quite like that of Rock Creek, a short distance to the northwest, where the Oligocene shales are covered by Pliocene tuffs and are succeeded westward by Eocene shales and underlying volcanics. The southern part of Columbia County, taken in connection with the adjoining portion of Washington County, probably affords the best ground in the State for studying the relations of the Eocene, Oligocene, and Miocene.

Extending south from Vernonia, the Oligocene soon passes under the Miocene, which forms the divide in that direction, and was not seen again along the eastern foot of the coast range until Polk County was reached. Very likely it crops out at many points along the range, especially along the higher portions of Gales Creek and Tualitin, for it appears again 8 miles northeast of Dallas, on the divide between McCoy and Derry, where 50 feet of sandstones with thin beds of gray shales are overlain by 40 feet of light-colored shales from the soft, crumbly sandstone, dipping 10° to the northeast. Numerous fossils were obtained. Of these only *Tritonium californicum* Gabb, *Trochita filosa* Gabb, *Cuma biplicata* Gabb, and *Clavella gravida* Gabb (?) were specifically identified, although eight other genera were represented. They were referred by Dr. Dall with doubt to the Oligocene. But this may well be correct, for the position of the strata shows that they lie beneath the Miocene strata seen to the northward and overlying the Eocene in the opposite direction. In the overlying light-colored shales no fossils were found. They look somewhat like the Miocene shales of Washington and Columbia counties, but so far as yet seen do not contain evident radiolarian or volcanic fragments.

The most southern outcrop of strata referred to the Oligocene is in Blodgett Valley, about a dozen miles west of Corvalis, on the road to Yaquina Bay. The shales and thin-bedded sandstones contain much volcanic material. They dip 40° to the northwest, and in a bluff north of the road 50 feet of them are well exposed. Half a mile northeast of Blodgett Station Mr. Anderson discovered in these tuffaceous beds fragments of *Aturia angustata*, with Ostrea, Pecten, Cardium, and Leda, which Dr. Dall referred with doubt to the Oligocene.

Turning now to the western slope of the Coast Range, the first locality of Oligocene south of Astoria is noted at Short Beach, in Clatsop County, where about 250 feet of thin sandstones and shales are exposed between projecting points of igneous rocks. Near the middle of the beach the upper beds of dark shale contain concretions in which were found *Dolium petrosum*, *Rostellites indurata* Conr., Arca, Macoma, Dentalium, and fish bones, indicating approximately the same age as the very lowest beds at Astoria and at Knappton, across the river. The only fossils found in the sandstones and shales on the coast between Astoria and Short Beach are Miocene. Directly eastward, about 6 miles from Short Beach, the Miocene occurs, near Crawford, and twice as far to the southeast is the Eocene, at Felix Roy's, on the Nehalem.

To the southward on Tillamook Bay at several points rocks are well exposed, and they are at least in part fossiliferous. At the entrance of the bay on the north side the ledges of sandstone and conglomerate dip southwest, with a southeast strike, carrying the beds across the bay toward the jetty quarries, where they are fossiliferous. The conglomerate occasionally contains pebbles 4 to 6 inches in diameter, and beneath the conglomerate and sandstones lie shales which, at Garibaldi, are hard and slaty; but this induration may, perhaps, be attributed to the eruptive rock near by. On the eastern shore of the bay, nearly midway between Hopkinsville and Bay City, are shales with concretions containing Dentalium and fish bones, and these shales are overlain by sandstones dipping gently to the southwest. Judging from the position of the strata exposed on the eastern side of the bay, they underlie those of the point northwest of Garibaldi and in the bluffs along which the jetty quarries occur.

Along the southwestern shore of the bay, from the mouth of the Tillamook River to the Spit, is a prominent bluff of soft, gray sandstone, from which the stones for the jetty have been obtained. At the southeastern end, in the old jetty quarry, about 80 feet are exposed, and it contains shells and casts throughout, although they are most abundant in the concretions, which are usually less than a foot in diameter. The strata dip gently to the southwest, as at other points on the shore of the bay, and strike more northerly than the face of the bluff, which, considering its whole length of nearly 3 miles, exposes several hundred feet of strata, almost wholly gray sandstones, generally so soft as to be readily crushed in the hand. When the fossils were collected in the old jetty quarry Mr. Anderson recognized the occurrence of Aturia[1] with Miocene forms, and it was considered evidence that Aturia survived into the Miocene. The determination of these fossils from the old jetty quarry by Dr. Dall proves of much interest. He finds the Oligocene forms *Aturia angustata* Conr., *Dolium petrosum* Conr., *Rimella simplex* Gabb, as well as the Miocene forms *Pecten propatulus* Conr., *Pyrula pyriformis* Gabb (?), *Crepidula prœrupta* Conr., *Lunatia* sp., *Bulla petrosa* Conr. (?), *Arca microdonta*, *Thracia trapezoides* Conr., *Venericardia subtenta* Conr., *Cryptodon bisectus* Conr., *Macoma arctata* Conr. (?), *Tapes staleyi* Gabb (?), besides species of Yoldia, Leda, Chione, and Modiolaria. In the field the strata were supposed to be Miocene, but it was not noted whether both Oligocene and Miocene fossils occurred in the same nodule. If they occur in different nodules it might be said that the Oligocene nodules were derived by erosion from strata of that age and deposited with the Miocene fossils where we now find them together. There was nothing whatever observed at the time the fossils were collected to suggest that they had not all lived together at the time the strata in which they occur were deposited. It is certain that Dolium continued into the Miocene, for it occurs in the Empire beds at Coos Bay. Although this exposure is described under the Oligocene, the predominance of Miocene forms would appear to show that it belongs rather to the Miocene.

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[1] According to Dall (Bull. U. S. Geol. Survey No. 84, p. 223), Professor Condon obtained an *Aturia ziczac* at Tillamook.

On the western slope of the Coast Range south of Tillamook Bay no Oligocene was observed, although it may well be there. At Coos Bay, where the Miocene (Empire beds) comes in contact with the Eocene (Arago beds), it was not observed.

MIOCENE.

The Miocene is widely distributed in western Oregon upon both sides of the Coast Range. It occurs over a large part of the Willamette Valley, especially in Washington, Yamhill, and Lane counties, and on the coast more or less continuously from Astoria to Coos Bay, and most likely beyond, with interruptions, to California.

Beginning at Astoria, the localities will be noted in order from north to south, first upon the eastern side of the range and then upon the western.

The Miocene of the Astoria region recognized by Dana consisted essentially of two members—sandstone above and shales below. By White and Dall the lower portion of the shales was shown to be older than the Miocene, but above the Aturia bed there was still recognized a mass of shale to which Condon's term Astoria shale was applied. Although Dall[1] at one time considered these shales as Miocene, he has since placed them under the Oligocene in his correlative tables.[2]

The age of the shales may yet be a matter of considerable doubt, but the overlying sandstone is without question referred to the Miocene. The upper part of the shales, where the thin, sandy layers begin to predominate, is shown in Pl. IX, from a photograph taken near the High School building in Astoria. They are cut by a small sandstone dike. For many years after Dana's visit to that region sandstone dikes were well exposed in Astoria and along the shore toward Tongue Point. They closely resemble those of Tehama County, Cal.,[3] where they have been shown to be earthquake fissures filled with sand from below. Dana regarded those at Astoria as fissures filled from above, and used the dikes as an argument to show the relative position of the sandstone and shale.

South of Astoria, on the eastern side of the Coast Range, the first Miocene strata observed were on the Nehalem, near Mist, in Columbia County. In the river the shales strike N. 22° W., and dip 13° to the southwest, so that ascending the river we appear to descend the series of rocks. A little farther up the river prominent bluffs of shale appear on the left bank. One hundred feet of whitish material consists chiefly of radiolarian fragments with some particles of pumice. This bed, as illustrated in fig. 6, overlies fossiliferous shale, of which only 10 feet are exposed. The strata are considerably faulted and crushed, and the fossils distorted. Dr. Dall recognized *Yoldia impressa* Conr., *Yoldia* n. sp., *Leda* n. sp., *Nucula divaricata* Conr., *Nucula truncata* Gabb, Dentalium two n. sp., and Lunatia sp., which he referred with some doubt to the Miocene.

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[1] Bull. U. S. Geol. Survey No. 84, pp. 223-226.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Part III.

[3] Bull. Geol. Soc. Am., Vol. I, p. 411.

The shales are cut by several sandstone dikes. The largest is very irregular, and ranges from 1 inch to 2 feet in thickness, and branches upward. It is composed of sand which is made up chiefly of volcanic material.

From Mist the river flows northwest for several miles and then turns southwest to cut across the Coast Range. There are few exposures by the road in that direction until Jewell is reached, where Oligocene or Eocene shale occurs.

Four miles up the river from Mist, near the mouth of Battle Creek, is a prominent bluff of fossiliferous sandstone. The strata are practically horizontal and associated with a small exposure of basalt. Among the fossils Dr. Dall reports *Mactra albaria* Conr., *Yoldia cooperi* Gabb, with Tellina, Solen, Macoma, Fusus, and Natica, which he refers to the Upper Miocene.

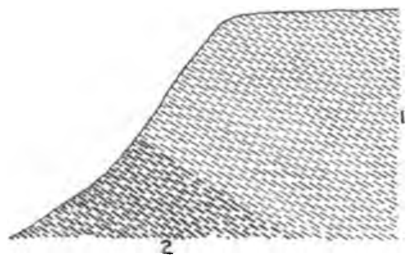
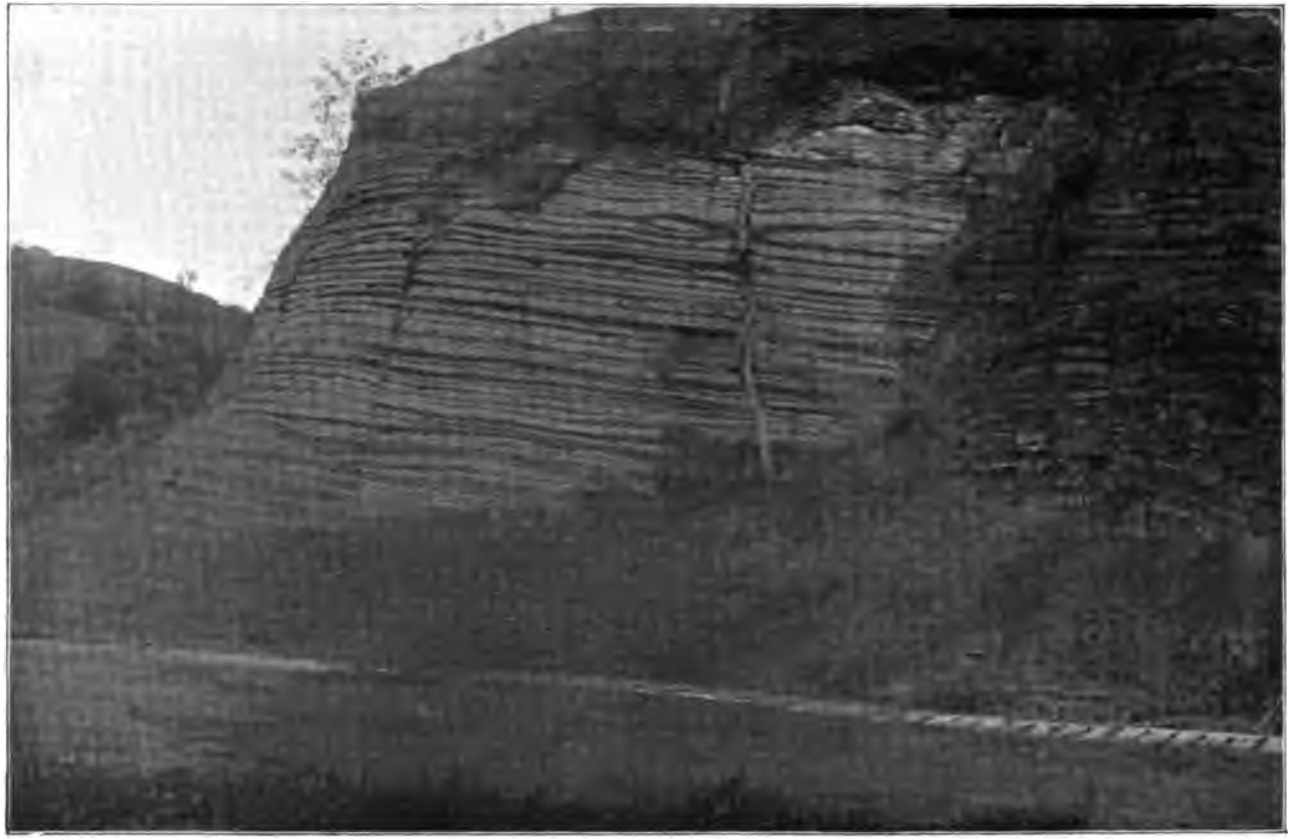


FIG. 6.—Section of left bank of Nehalem River, near Mist. 1, Whitish, tuffaceous radiolarian shale; 2, Fossiliferous dark shale.

On the East Fork of the Nehalem, about 6 miles southeast of Pittsburg, and belonging apparently to a higher horizon than the sandstone and shales of that place, is a soft, yellowish sandstone associated with a bed of coal 4 to 6 feet in thickness. Among the few fossils found there are *Callista angustifrons* Conr., *Mactra albaria* Conr., and others which Dr. Dall refers doubtfully to the Miocene. These fossils are quite unlike those (Eocene) associated with the coal on Pebble Creek, and indicate that the coal of the two localities does not belong to the same bed.

The divide between the Nehalem River and Dairy Creek, especially the southern slope, is composed of Miocene strata. The lower strata appearing to the westward are chiefly shales, while the upper ones are for the most part sandstones.

On Gales Creek, a mile above the post-office, over 100 feet of dark shales, dipping 40° to the southeast, are exposed in the bed of the stream, and a short distance farther down contain Mytilus, Macoma, Lyonsia, and Yoldia. The species are all new, but are regarded by Dr. Dall as probably Miocene.



ASTORIA SHALES AND SANDSTONE DIKE.

On the West Fork of Dairy Creek both sandstones and shales occur. The latter are dark within, but weather gray, and when freshly broken have a decided odor of petroleum. The best exposure is in sec. 32, T. 3 N., R. 4 W., where a large landslide has occurred, exposing 250 feet of the shale. It is rather massive than fissile, and contains, besides occasional casts of mollusks, numerous small fragments of carbonized vegetal matter and minute bright scales of muscovite. Under the microscope it is seen to contain some volcanic material, also traces of radiolaria, and occasional green grains of glauconite. The fossils found here, *Yoldia impressa* Conr., *Callista angustifrons*, *Lucina acutilineata* Conr., with others not specifically determinable, are referred to the Miocene. The occurrence of bituminous light-colored shales in Oregon containing radiolarian and volcanic fragments is of much interest on account of their close resemblance to the Monterey shales of California. By the kindness of Prof. A. C. Lawson, of the State University of California, who sent me a number of samples of the Monterey shales, I am able to compare them. Although those of Oregon are generally not so light colored, they are occasionally almost as white as chalk. Generally, however, there is no trace of bituminous matter about them, at least so far as one may judge from surface indications.

On the West Fork of Dairy Creek these shales dip gently eastward, beneath the soft sandstones exposed lower down on the same stream. On the East Fork of Dairy Creek the sandstone is approximately horizontal, and occasionally very fossiliferous. A coulée of basalt cascades over the side of the canyon 4 miles above Mountain Dale. A collection of fossils was obtained at this point, and Dr. Dall recognized *Nucula divaricata* Conr., *Yoldia cooperii* Gabb, *Mactra albaria* Conr., *Mya præcisa* Gld., *Crepidula prærupta* Conr., and other forms, which he regarded as indicating a horizon well up in the Miocene.

The same group of strata extends northeast to the Scappoose, where, in section 34, by the kindness of Dr. David Raffety, specimens of *Mactra albaria* Conr. and other forms were obtained. A short distance farther up the same stream, at the mouth of Fall Creek, the Oligocene occurs.

Southward from Forest Grove an excellent exposure of dark-gray fossiliferous Miocene sandstone occurs at Boos's quarry, near Dilley. At least 100 feet of sandstone is exposed, dipping to the northeast at an angle of from 34° to 41°. Fossils are abundant, and evidently Miocene. On the Scoggins Creek road, a short distance above the road to Boos's quarry, a series of fossiliferous strata occur in essentially the same position as those at the quarry.

At the south end of Wapato Lake, on the road crossing to the base of Chehalem, there are shales which stand out in the valley farther from the foothills of the Coast Range than the two localities last mentioned. In the calcareous nodules of the shales *Pseudamusium peckhami* (?) Gabb and other Miocene forms were obtained. A prominent hill called Chehalem is capped by basalt. Although Chehalem Valley is remarkable for its fertility and rural beauty, it affords few exposures of rocks except those of basalt upon the hills. After leaving Wapato no Miocene was encountered until near the southern border of Benton County.

A few years ago Mr. John Ray sent to the National Museum fossils from Foster's ranch, about 12 miles southwest of Corvallis, and they were referred by Dr. Dall to the Miocene. It is probable that they were collected to the east of the locality from which the Eocene fossils previously mentioned were obtained.

In the gray sandstone quarry on the road within a quarter of a mile west of Monroe a few fossils were found, among which Dr. Dall recognized *Crisotrema condoni* Dall, *Mactra albaria* Gabb, with Trochita, Crepidula, Fusus, Crassatellites, and Dentalium, and referred them to the Miocene. The sandstone dips gently toward the Willamette only a few miles to the eastward, and is probably continuous with similar beds near Eugene, where numerous characteristic fossils have been found by Condon and Dall.[1]

It is generally believed that the Miocene east of the Coast Range does not extend farther south than to the head of the Willamette Valley, but a suggestion has recently been found in some fossils collected near Oakland that it extends into Douglas County. In the calcareous shales near the forks of the road one-half mile east of Oakland, *Lucina acutilineata* Conr. was obtained. Dr. Dall informs me that it is known only in the Miocene, and is believed to be characteristic. The number of fossils, however, is small, and they occur in a region apparently surrounded by Eocene, so that their presence can scarcely be regarded as more than a suggestion.

Upon the western side of the Coast Range, south of Astoria, the first strata supposed to be Miocene were observed at Tillamook Head, where Professor Dana[2] reported a cliff of light and dark blue clay 900 feet in height.

At the northern end of the head, near Seaside, light-colored shales with occasional concretions occur. No large fossils were seen, but the radiolarian tuff is quite like that which occurs at Mist and elsewhere in the Miocene shales, so that there can be little doubt as to its position. Farther along, the strata are somewhat more sandy, and are succeeded by cliffs of basalt, rendering the shore impassable for a number of miles.

Near Seaside the road leaves the beach and crosses Tillamook Head to Cannon Beach. Outcrops of both shale and basalt occur by the way. At the southern side of Tillamook Head the sedimentary rocks appearing with the eruptives are thin-bedded. The sandstones, ranging in thickness from 5 to 18 inches, are separated by thin shales. The eruptives contain many veins and nodules of calcite, and some of quartz.

Below the mouth of Elk Creek, along Cannon Beach, are fine exposures of conglomerate, sandstone, and shales over 60 feet in thickness, cut by irregular dikes of basalt. The sedimentary rocks are soft, like the Merced series of Lawson on the coast near San Francisco. But the few fossils they contain near Haystack Rock—Nucula, Leda, and Tellina—are not specifically identifiable, and Dr. Dall relegated them with doubt to the Miocene. Shales are most abundant. They strike N. 13° W., and dip 23° to the northeast, but the position is variable. Normal faults are common, and trend nearly parallel to the strike of the strata, with the downthrow to the northward. Nearing Mrs. Austin's, at Cannon Beach post-office, sandstones with beds of pebbles form prominent outcrops, in which the waves have carved caverns.

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[1] Bull. U. S. Geol. Survey No. 84, p. 227.

[2] Wilkes Exploring Expedition, Vol. X, Geology, by Dana, p. 653.

Cannon Beach is about 9 miles in length, and is limited to the south by Arch Cape, composed of basalt, which is in part overlain by soft, yellowish sandstone. Short Beach, which lies on the south, next to False Tillamook, exposes a series of Oligocene strata, and Neahkahnie Mountain beyond, of igneous rocks, forms a bold promontory.

No fossils were found in immediate connection with the coal in the Lower Nehalem basin, but at Crawford's, on the North Fork, about 6 miles above the post-office of Nehalem, there are soft shales, locally calcareous and much crushed, containing a few forms. The fossils are contained in the calcareous layers and nodules, and among them Dr. Dall identified *Mactra albaria* Conr., *Yoldia impressa* Conr., *Arca obispoana* Conr., *Pecten propatulus*, and *Trochita filosa*, which he refers to the Miocene.

A few miles southeast of Crawford's the volcanic Eocene occurs on the Nehalem at Felix Roy's, but down the coast the Miocene was not recognized again until Tillamook Bay was reached. In the heavy mass of sandstone at this point there is such a mixing of characteristic Oligocene and Miocene species that the age of the beds is a matter of doubt. Although it is believed that they are essentially Miocene, they were described and the fossils noted under Oligocene.

The shore between Tillamook Bay and Oyster Bay is a line of bold basalt bluffs, but occasional masses of sandstone are included in the eruptives, as may be seen on the beach south of Meares Point light. Between Meares Point and Otter Rock, near Yaquina Bay, there have been few if any geological observations on the coast, and the character of the exposed rocks is not known. The occurrence of several prominent heads suggests the presence of eruptives that locally interrupt the continuity of the sandstones.

In the region of the Yaquina Bay, extending north beyond Otter Rock, the Miocene has its greatest development on the coast of Oregon and is well characterized by an abundance of fossils. A general view at this point is illustrated in Pl. X. The strike of the strata about Otter Rock varies from N. 8° to 13° W., with a westerly dip at an angle of about 18°. The abrupt change of sediments at the southern end of the rock, where the road ascends to the top of the terrace and the small exposure of the light-colored Miocene beds is greatly fractured, suggests displacement of the strata. This suggestion is emphasized by the small faults well exposed on the north side of Otter Rock. That no great displacement occurs, however, is clearly indicated by the fact that the thin-bedded yellowish sandstone of which Otter Rock is composed contains a few miocene fossils, which relate it quite closely to the fossiliferous beds a short distance on both sides.

South of Otter Rock to the point at Newport, and along the bay to the town of Yaquina, the rocks are chiefly shales, generally fossiliferous, and dipping toward the sea. At Yaquina calcareous concretions are abundant and full of fossils. In the collections between Yaquina and Otter Rock, along the coast, Dr. Dall identified the following forms:

1. Otter Rock and along the beach 1 mile northward:

Margarita striata Brod., and the common Arca, Natica, and Callista, Mactra albaria Conr.

2. On the beach from Otter Rock south to Cape Foulweather:

Pecten propatulus Conr.
Tellina arctata Conr.
Panopea abrupta Conr.
Callista angustifrons Conr.
Arca microdonta Conr.
Nucula conradi Week.
Sigaretus scopulosus Conr.
Pyrula modesta Conr.
Crepidula prærupta Conr.
Large Pleurotoma and Buccinum.

3. Nye Beach to Cape Foulweather:

Crepidula prærupta Conr.
Euthria like dira Roe.
Purpura n. sp. (?)
Natica sp.
Leda like cœlata Hinds.
Yoldia sp.
Arca microdonta Conr.
Arca inezana Conr.

4. North beach of Yaquina Bay:

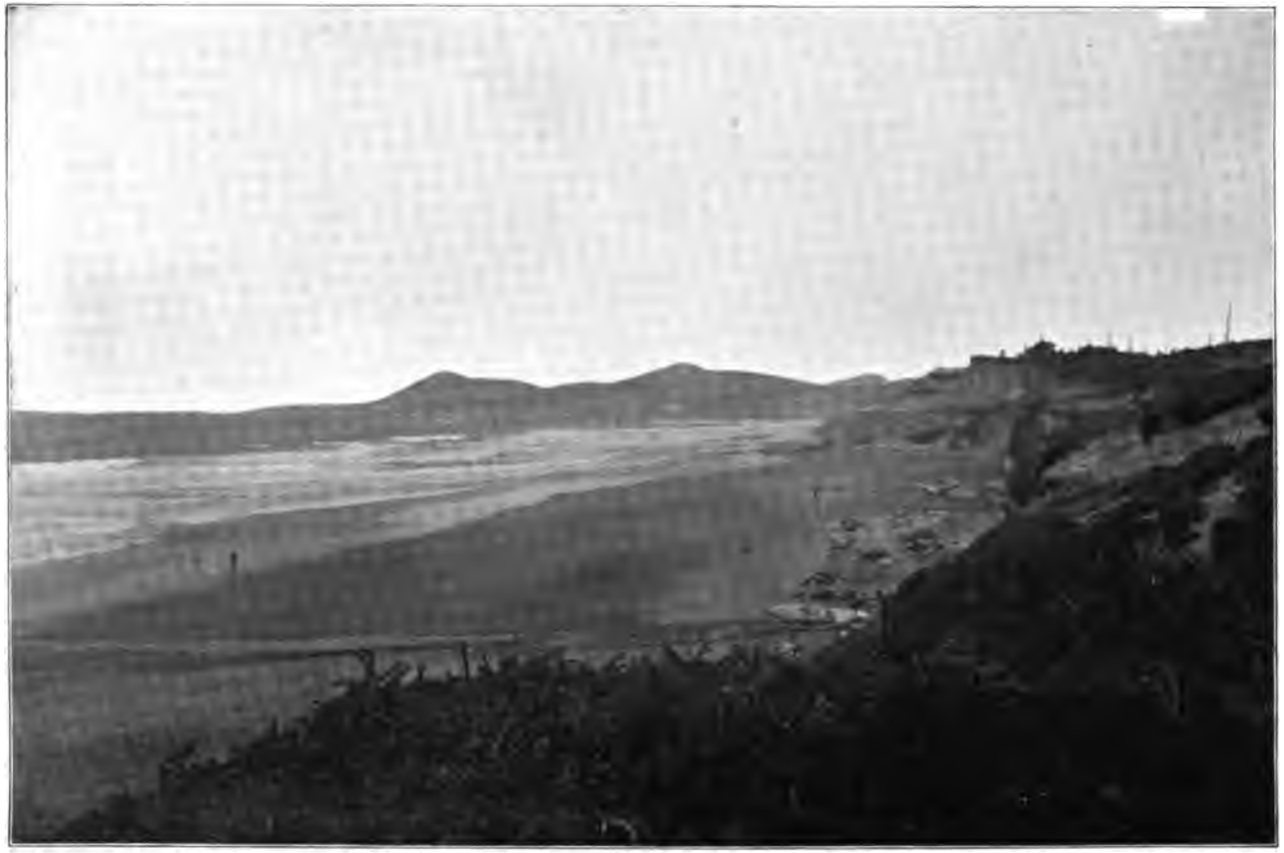
Nucula truncata Gabb.
Lucina acutilineata Conr.
Natica sp. undet.

5. East shore of Yaquina Bay:

Mytilus (large).
Macoma.
Callista.
Lutricola unda Conr. (?)
Lucina.
Callicardia. (?)
Cardium.
Mya præcisa Gold.
Arca microdonta Conr.
Yoldia impressa Conr.
Dentalium n. sp.
Trochita filosa Gabb.
Pleurotoma like circinata Dall.
Buccinum like plecteum Stm.

Shaly sandstones begin near Yaquina, and according to Mr. Anderson they are succeeded by massive beds to the eastward, along the Yaquina River. In a railroad cut at Rocky Point, 4 miles east of the town, dark shales appear and contain many calcareous concretions, in which the following fossils were found:

Nucula conradi Week.
Modiola sp.
Tellina arctata Conr.
Macoma sp.
Callista angustifrons Conr.
Cardium modestum Ad. and Roe.
Lucina acutilineata Conr.
Crepidula prærupta Conr.
Dolium petrosum Conr.



VIEW LOOKING NORTH ALONG NYE BEACH TO CAPE FOULWEATHER.

It appears that the sandstone just referred to lies beneath the shales of the coast and overlies those of Rocky Point. This sandstone, so far as can be judged from what is already known of its position, is possibly the one exposed in the Yaquina coal field west of Depot Slough, where in Jones Tunnel fragments of Mytilus, Macoma, Mactra, Yoldia, Dentalium, and Natica were found, and referred by Dall, with doubt, to the Miocene.

To the eastward of Toledo there are a few outcrops before reaching Pioneer, where massive sandstone is well exposed and extensively quarried. It is gray and rather soft, so as to be easily removed and carved. The thickest blocks obtainable are about 10 feet. Other layers range as low as 4 feet, and they are separated by films of clay.

Near Pioneer the sandstones strike east and west, with a dip of 20° to the northward. Beyond Pioneer shales become more prominent again, intermingled with soft sandstones, and continue toward the summit. No fossils were found east of Pioneer. The incoherent character of the beds and their gentle inclination (with few exceptions much disturbed) suggest that they may be younger than the upturned fossiliferous strata of the coast. Elevated beaches are occasionally well marked, and it appears that at no very remote epoch, geologically, the sea may have passed through the low gap into the Willamette Valley. The soft sandstones and shales continue east of the summit to near Blodgett Valley, where they are replaced by beds of volcanic material and old lavas like those seen on the Nehalem.

The strike of the Miocene rocks at Yaquina carried them down the coast, and their occurrence with an abundance of fossils at Coos Bay indicates that they are continuous between these two points. The Miocene rocks of Coos Bay are well exposed on the beach 3 miles southwest of Empire City, between Pigeon Point and Fossil Point. They are so well characterized at this locality by their fossil contents and position with reference to the adjoining rocks that we designate them the "Empire beds." These beds are more sandy than at Yaquina, and contain numerous fossils. On the wave-cut terrace they appear to be horizontal, but structural lines show here and there, indicating that the strike varies from N. 7° to 10° W., and the dip from 7° to 11° SW. Concretions are common and contain most of the fossils, but *Pecten propatulus* and some other forms are scattered throughout the Empire beds. From the collections made Dr. Dall reports:

Crepidula prærupta Conr.
Dolium petrosum Conr.
Lunatia sp.
Pectunculus patulus Conr.
Yoldia near lanceolata Sby.
Pecten propatulus Conr.
Callista angustifrons Conr.
Mactra albaria Conr.
Cryptoda bisectus Conr.
Thracia trapezoides Conr.

The distance from one point to the other along the shore is only about three-eighths of a mile, and owing to the gentle dip of the strata less than 300 feet (estimated) are exposed. The Empire beds may be seen for some distance along the east shore of South Slough and along the mouth of the bay from South Slough toward Cape Arago as far as Coos Head. In the bluff east of Coos Head the massive Miocene sandstone containing occasional valves of *Pecten propatulus* strikes N. 25° W. and dips 18° to the northeast. This massive sandstone, with its gentle dip, extends westward along the shore from Coos Head only a short distance, for before reaching Tunnel Point the highly inclined Arago beds (Eocene) form the bluff. The Empire beds and the Arago beds meet between Tunnel Point and Coos Head, and there is every indication that they are markedly unconformable.

At Fossil Point occurs the most remarkable fossiliferous rock seen anywhere on the coast. Owing to the very large number of perfect fossil shells it contains, it is locally known as Fossil Rock. It is of small extent, and rests directly and unconformably upon an eroded surface of the Empire beds. The contact is plainly visible. It is evident, therefore, that the Empire beds are not only well characterized by fossils, but are limited both above and below by unconformities.

It is probable that the Empire beds extend some distance toward the Coquille, for on the beach at the mouth of Twomile Creek were found a number of Miocene fossils brought down by that stream, and according to Newbury[1] and Condon, a narrow strip of arenaceous Miocene rocks extends more or less continuously from Cape Blanco to Port Orford.

PLIOCENE.

Of the many lots of fossils collected during this reconnaissance in northwestern Oregon, only two have been definitely referred by Dr. Dall to the Pliocene. Both were obtained in Columbia County, one from Rock Creek, about 4 miles above Vernonia, and the other from the north slope of the mountain by the western road from Clatskanie to Mist, at an altitude of 700 feet above the sea.

Going up Rock Creek from Vernonia one finds shales exposed here and there along the road, overlain by a light-colored tuff which in places looks very like a sandstone, but under the microscope it is seen to be composed wholly of volcanic dust. The shales, judging from those on the Nehalem above Vernonia, are probably Oligocene, and are in unconformable contact with the tuff. The tuff forms a conspicuous bluff, which had to be excavated to allow the road to pass above the stream. In the loose fragments at the bottom of this bluff a few fossils were collected, among which Dr. Dall recognized *Yoldia cooperi* Gabb, Macoma sp., *Terrebratulina anguicula* Cpr., *Opalia ruderata* Dall n. sp., Pleurotoma n. sp., and Dentalium n. sp., and remarks that they belong to the Pliocene (horizon of Pacific Beach, San Diego, Cal.) and indicate rather deep water.

The light-colored rock of the bluff contains not only the fossils already enumerated, which are visible to the unaided eye, but also multitudes of radiolarian fragments. Many of the latter are readily recognized by their dark honeycomb or reticulated structure, but others, derived from the spines or cellular spaces of the radiolarian skeletons, show no mark of their organic nature and look like fragments of volcanic glass. There are, however, some particles of pumice present, and in general they may be distinguished from the radiolarian spines by the bubbles of gas or inclusions of differently colored glass which they contain. The bed of radiolarian tuff is about 70 feet in thickness and nearly horizontal. Its laterial extent is not known, but it must be considerable, for the fossils it contains indicate its marine deposition in rather deep water.

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[1] Bull. U. S. Geol. Survey No. 84, p. 223, footnotes 1 and 2.

The second locality of Pliocene to be noted is on the western road from Mist to Clatskanie. The summit of the divide by the road is sandstone, at an altitude of about 1,200 feet, although farther east it is capped by lava and is considerably higher. At an elevation of about 700 feet, in soft shaly sandstone, *Yoldia impressa* Conr., *Solemya ventricosa* Conr., and *Lucina acutilineata* Conr. were found, and referred to the Pliocene. Farther down upon the same slope, in a similar sandstone, numerous Oligocene fossils were obtained.

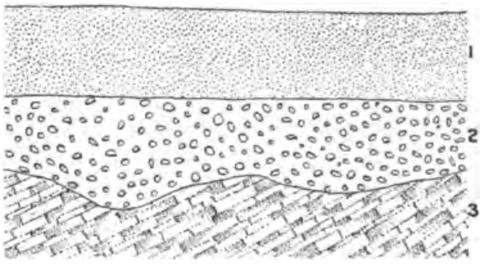

Fig. 7.—Section at Fossil Rock. 1, Sand (Pleistocene); 2, Fossil Rock (Pliocene); 3, Sandstone (Miocene).

Although Pliocene strata may be quite widely distributed in northwestern Oregon in places we did not examine, it does not appear probable, for the only other locality of marine sediments known that can be referred to the Pliocene, excepting, perhaps, the upper Miocene on the Nehalem, 4 miles above Mist, is the remarkable "Fossil Rock" on Coos Bay, 3¼ miles southwest of Empire.

This rock, well known in the community as Fossil Rock, is essentially a conglomerate. Besides a great abundance of almost perfect shells, it is composed of pebbles and angular blocks and concretions of the Miocene sandstone (Empire beds), upon which it rests unconformably, as illustrated in fig. 7. The contact of Fossil Rock and the Empire beds is clear, and there can be no question that the Empire beds were consolidated and eroded, and that thus many of their fragments and fossils were mingled with the then living forms of which Fossil Rock is composed.

The large number of shells accumulated upon the Empire beds in some of the little coves near by illustrate the way in which Fossil Rock was formed. It is important to bear in mind, however, that, as shown by Mr. Walcott[1] in considering intraformational conglomerates, it may be possible for just such material as Fossil Rock to form essentially contemporaneously with the beds of whose fragments it is composed.

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[1] Bull. Geol. Soc. America, Vol. V, p. 191-198.

The close correspondence of the fossils to those of the underlying Empire beds relegates it to the Miocene, but the apparent physical break shown by the relation of the beds indicates that it may be considerably younger than that portion of the Miocene represented by the Empire beds. It is certainly older than the Pleistocene beds by which, as seen in fig. 7, it is overlain.

In the collection from Fossil Rock Dr. Dall recognized *Chrysdomus* like *fornicatus* Gray, *Lunatia* sp., *Crepidula prærupta* Conr., *Pecten propatulus* Conr., *Tapes staminea* (Staleyi (?) Gabb), *Mactra albaria* Conr., Dione, Chione, Cardium, Macoma, and *Callista angustifrons* Conr., and referred them to the Upper Miocene, remarking, "This assembly is about like that which Merriam lists (letter of Prof. A. C. Lawson, June 18, 1895) from Coos Bay," and to which Lawson[1] referred in suggesting that the Wild-cat series (Pliocene) extends as far north as Coos Bay.

Fossil Rock is as firm as the Empire beds on which it rests, but is of limited extent, covering an area of only about 1 acre, with a thickness of less than 20 feet. Beds corresponding to Fossil Rock were not discovered anywhere else in the neighborhood, or along the coast elsewhere, unless at Hinton Point, opposite Newport, on the Yaquina Bay, where Professor Condon is of the opinion that the Pliocene occurs. The deposits at Hinton Point are noted more particularly under Pleistocene. Strata continuous with Fossil Rock would not be expected to extend inland, for it is a characteristic shore deposit.

The only other matter to be considered under the head of Pliocene is the occurrence of a mastodon tusk at Gravel Ford, on the North Fork of the Coquille, 7 miles from Myrtle Point. It was taken from the bank 9 feet above the level of the river, and is said by Mr. Orville Dodge, from whom I obtained fragments of the tusk, to have been 3 feet in length. Mr. F. A. Lucas, of the U. S. National Museum, examined the fragments and identified them as parts of the tusk of a mastodon which lived probably during the Pliocene period. The tusk had a peculiar enamel band.

From the small amount of evidence at hand concerning Pliocene geography, it seems that the Klamath Mountains, and the larger portion if not the whole of the Coast Range, were above the sea during that period. Besides the little strip at the mouth of Coos Bay, the only land of northwest Oregon now known to have been covered by the Pliocene sea lay in Columbia County, near the east base of the Coast Range. It is very probable, however, that the Willamette Valley was then filled by the sea, for, as we shall see in the sequel, Willamette Sound filled it for a portion of the next succeeding period.

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[1] Bull. Univ. of California, Department of Geology, Vol. I, p. 256.

PLEISTOCENE.

Under the Pleistocene are considered all those deposits which are more recent than the Pliocene. They are not distinguished in general so much by fossils as by the unconsolidated character of the deposit and its position. They are widely distributed, and will be described in the order of their occurrence from the Columbia southward, but in this case first upon the west slope of the Coast Range and then upon the east, and in the Willamette Valley.

At Ilwaco, on the north bank of the Columbia near its mouth, is an exposure of which a sketch is shown in fig. 8. The upturned edges of the Astoria shales make the mass of the hill, and these shales are unconformably overlain about 30 feet above sea level by a series of gravel, sand, and clay layers 14 feet thick. The material in these layers is incoherent and contains occasional fresh fragments of shells belonging to species yet living on the coast. Near the middle of the deposit is a dark seam of vegetal matter, and the character of the stratification is such as to indicate that the deposit is waterlaid and not of eolian origin.

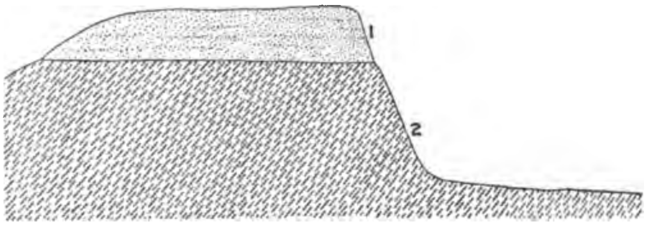


FIG. 8.—Section of shore near Ilwaco, showing a layer of Pleistocene sand (1) unconformably overlying tilted shales (2).

At the base of the hill the upturned edges of the shales have been cut off to an even surface by the waves, and this wave-cut terrace extends more than 100 yards toward the river. The top of the shales, in the hill immediately beneath the Pleistocene layer, is planed off in the same way, and it is evident that when this was accomplished the shale in the hilltop was then at the sea level and the waves rolled over it as they now roll over the lower wave-cut terrace to reach the beach.

The Pleistocene capping of the hill was laid down when the ancient wave-cut terrace was below the sea level deep enough to receive the deposits we now find there. Since then, of course, it has been raised to its present elevation by a general, perhaps more or less unequal, uplifting of the land along the coast.

Going south from the Columbia, along the Clatsop coast, one's attention is first attracted by the remarkable series of ridges, of which more particular mention has been already made in this paper under the head of "Features of the Oregon coast." At Tillamook Head and False Tillamook there are prominent cliffs along the beach, but late deposits, corresponding to those noted at Ilwaco, although doubtless present, are not well exposed.

Below the mouth of the Nehalem, however, they appear in the sea cliff by the beach. As shown in the following section, fig. 9, the strata are horizontal, and, beginning below, consist of (*a*) bony, carbonaceous clay, 5 feet; (*b*) sand, 3 feet; (*c*) gravel, stumps, logs, etc., 5 feet; (*d*) sandy clay, 12 feet; making a total thickness of 25 feet. A small stream reaches the beach by a little gulch cut through a 25-foot bluff containing these strata. The stream has cut down to the bony, carbonaceous layer, and from the top of that layer it falls to the beach. The stream is so small that it works slowly, and has failed to cut down to sea level, as have the larger streams. Such a fall in a large stream might be taken to indicate a very recent uplift along the coast at that point.

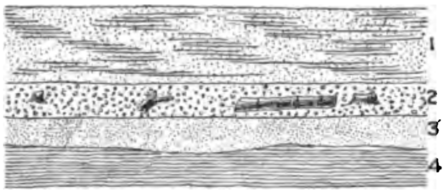


FIG. 9.—Section of sea cliff below the mouth of the Nehalem. 1, Sand and clay, 12 ft.; 2, Gravel, stumps, logs, etc., 5 ft.; 3, Sand, 1-3 ft.; 4, Carbonaceous clay, 5 ft.

South of Tillamook Bay is a prominent bluff where the Meares Point light-house is located. Near by is a bluff of basalt, estimated to be about 300 feet in height, capped by 20 feet of soft sandstone, which belongs to the series of comparatively incoherent Pleistocene deposits. This was not examined close at hand, but the stratification appeared distinct, as if the deposit had been waterlaid, and lacked the irregularities characteristic of dune sand. The exposure is illustrated in the accompanying fig. 10.

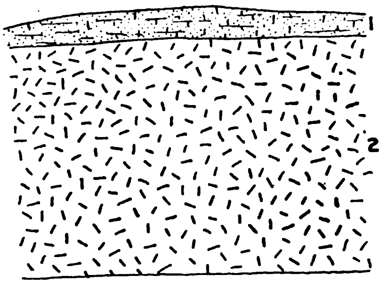


FIG. 10.—Section near Meares Point light-house. 1, Soft sandstone, 20 ft.; 2, Basalt, 300 ft.

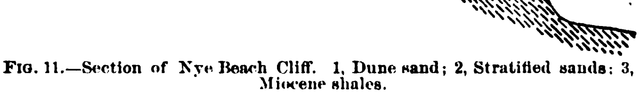
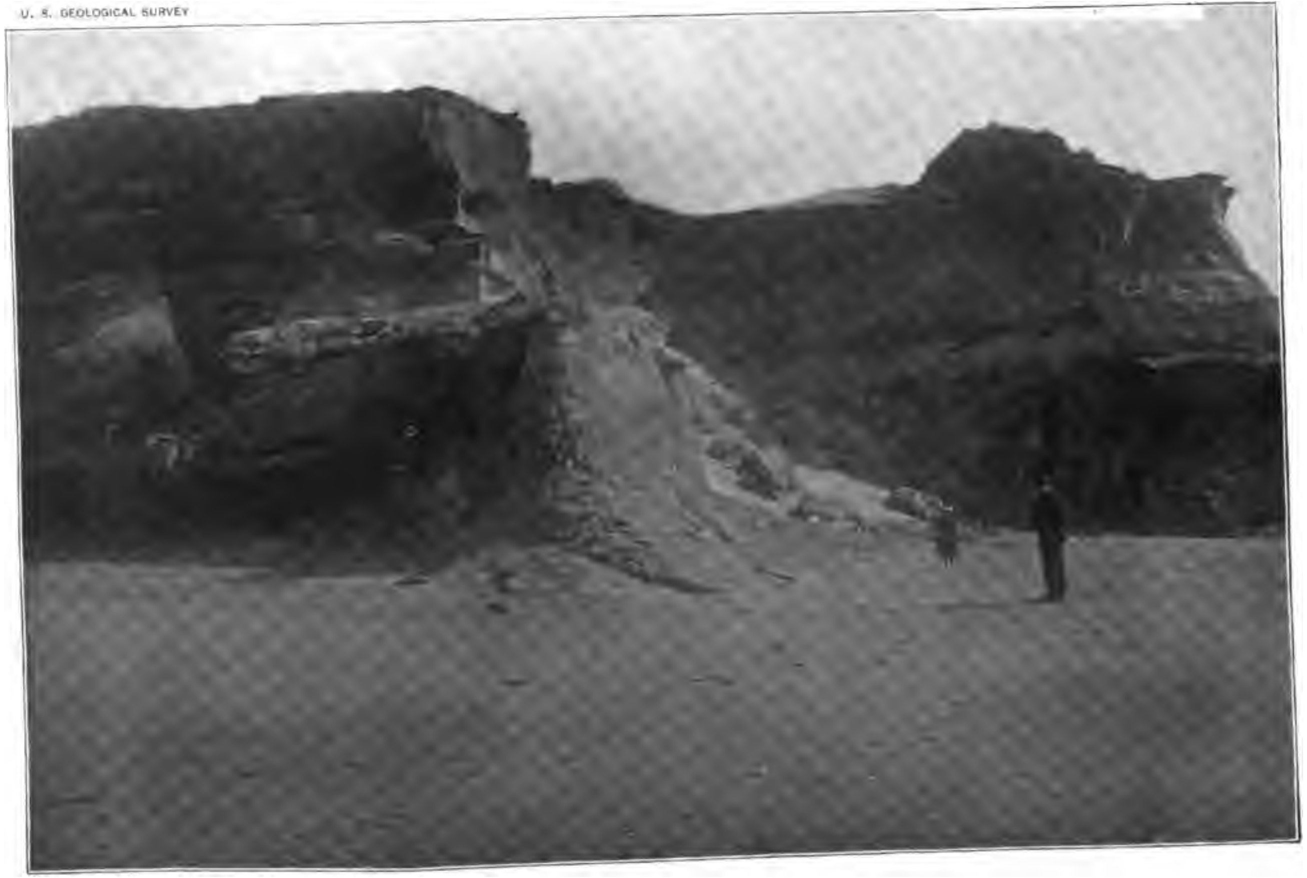


FIG. 11.—Section of Nye Beach Cliff. 1, Dune sand; 2, Stratified sands; 3, Miocene shales.

It is in the region of Yaquina Bay, however, that the most extensive exposure of this formation was seen. The following section (fig. 11) illustrates what may be seen at Nye Beach. The top of the hill, which is 100 feet above the beach, is dune sand. The edge of the sea cliff is dune sand, resting on a layer containing a stump of a tree in place. Beneath it is chiefly sand, not fully exposed, and the whole



NYE BEACH CLIFF.

mass rests on the upturned edges of the Miocene shales, which are very fossiliferous and incline seaward at an angle of 20°. About 100 yards farther north the contact of the sand and shales is well exposed. Pl. XI is from a photograph taken at this place, and fig. 12 is a section. The lowest portion of the Pleistocene rests, with marked unconformity, directly on the Miocene, and is composed of angular fragments of shale and sandstone. The upper part of this layer is chiefly sand, partially stratified, and contains wood, logs, limbs, and roots, some of which look as if they were still in the places where they grew. Much gravel and angular fragments are mixed with the sand. Succeeding layers (2) are composed chiefly of sand, with angular fragments and small pieces of wood. It is clearly stratified, with cross-bedding, and in places is stained yellow by oxide of iron. The upper layers (1), having a thickness of about 20 feet, are evenly stratified gray sands, in a horizontal position. The Pleistocene at this exposure has a thickness of about 40 feet, and the lower portions (2 and 3) dip gently eastward with the slope on which they were deposited.

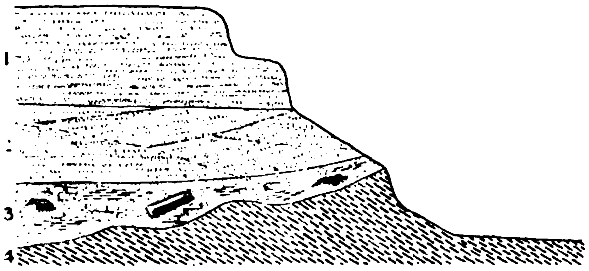


Fig. 12.—Section of Nye Beach Cliff. 1, 20 feet of gray sands, well stratified; 2, Chiefly cross-bedded sands, 12 ft.; 3, Fragments of shale, sandstone, and sand containing wood; 4, Miocene shales.

A short distance farther north, on the beach beyond the mouth of Nye Creek, the following section (fig. 13) exposes about 35 feet of strata. Beneath 18 inches of soil is a bed of sand 6 feet thick, and next below it is a bed of gravel, partially indurated, 5 feet thick. Then come 10 feet of yellow sands with occasional pebbles, and the bottom of the series is not exposed. The exposure is of interest when compared with the others, in containing a bed of well-rounded pebbles. This bed, like another near by in the same bluff, is of small lateral extent, yet it is well interstratified with sands.

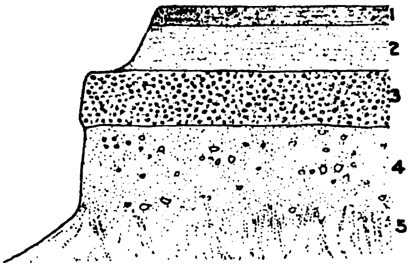


Fig. 13.—Section of Nye Beach Cliff. 1, Soil. 18 inches; 2, Sand, yellow and gray, 6 ft.; 3, Gravel, 5 ft.; 4, Sand, with occasional pebbles, 10 ft.; 5, Talus.

The same series of strata is well exposed near Newport, where the grade is cut through the hill toward Nye Beach. The cliff exposes about 80 feet of strata, in which sand prevails, but layers of gravel are common toward the top. Near the base the beds are finer and some of the layers contain considerable vegetal matter, among which are numerous cones. These have been examined by Mr. Knowlton, who pronounced them *Picea stichensis* Carr., the tide-land spruce, which reaches its greatest development to-day in the region about the mouth of the Columbia, but extends as far north as Alaska. Professor Condon called my attention to this locality, and informed me that he had collected a number of marine mollusks here, indicating that the deposit was laid down in the sea.

If marine shells are generally scarce in the Pleistocene deposits about Yaquina Bay, there is one locality, to which my attention was directed by Professor Condon, where they are abundant enough to make up for the deficiency elsewhere. It is in a small recess of the cliff near the Point, about one-half mile southwest of Newport. The section at that place, which represents nearly 100 feet in thickness, is illustrated in fig. 14. The upper layer is wind-blown sand; below it is a thick mass of stratified, yellowish sand, which is sometimes partially cemented so as to form a soft sandstone. It closely resembles material in the upper portion of the section represented in fig. 12. Below this, partly concealed by talus, comes a mass of clay which extends to the bottom. It is in places distinctly stratified, and contains a multitude of marine shells, of which a large collection was made. This clay rests unconformably upon the irregular surface of the Miocene shales, and, near the contact, is composed chiefly of shale fragments. A log lies confined along the western contact, which is plainly in view. On the eastern side of the exposure the large mass of talus conceals nearly everything. The small portion of the contact between the shale and the overlying clay was laid bare by excavating. At the top of the clay there is a weed-covered bench which looks as if formed by a landslide; but a little examination of the composition, structure, and relative position of various parts of the section here exposed shows that this can not be so. The bench, instead of being produced by a landslide, is due to the presence of springs. The water, which readily percolates the overlying beds of sand, reaches the impervious clay, which drains it to the surface, where it washes away the sand to produce the bench.

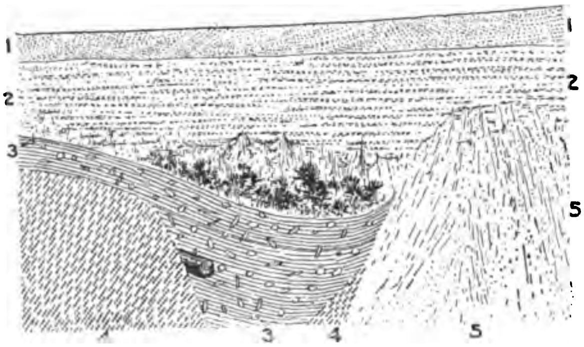
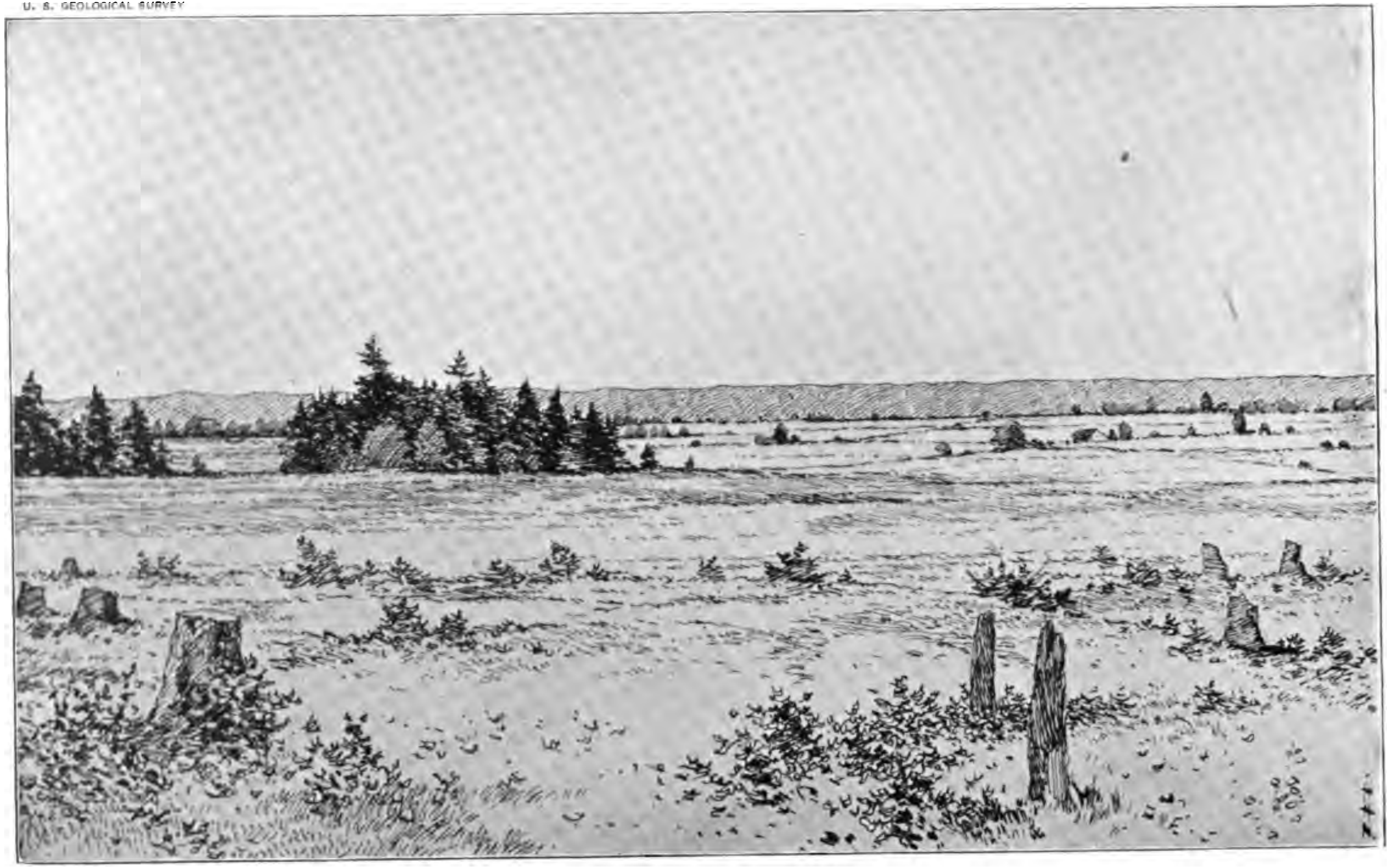


FIG. 14.—Section of cliff near Newport Point. 1, Dune sand; 2, Stratified sand; 3, Clay full of shells; 4, Miocene shales; 5, Talus.

The great abundance of shells, among which Dr. Dall recognized *Monia macroschisma* Desh., *Macoma nasuta* Conr., *Saxidomus aratus* Gld., *Tapes staminea* Conr., *Zirphæa crispata* L., and *Purpura crispata* Martyn., all of which are living forms, shows not only that at least the



VIEW LOOKING NORTH FROM FOREST GROVE.

v. p 47.

basal portion of the mass is of marine origin, but that it is of Pleistocene age. In the upper part of the clay that contains shells a cone was found like the cones at the base of the bluff at Newport. Both exposures occur in the same bluff one-half mile apart, and this common fossil serves to connect them still more closely.

From the heights, near the schoolhouse at Newport, looking southeast across the bay, Hinton Point is in fair view. It is well stratified from base to summit. In the upper three-fourths of the bluff, according to Professor Condon, who has examined the locality, the deposits are sandy, corresponding to those exposed at Newport, but beneath them the horizontal strata are argillaceous. The bottom of the clay is not exposed. It lies below the bottom of the bay. Between the sand and clay water escapes, as at the locality just noted, one-half mile southwest of Newport. Professor Condon has collected a large number of fossils from the clay bed at Hinton Point, and reports that Macoma and other members of the same family are abundant. He regards the basal portion of this section as probably Pliocene. The only fossil collected from the Pleistocene north of Newport Point was at the foot of the bluff near the mouth of Nye Creek. James Storrs found in the sand fallen from the cliff a large tooth which Mr. F. A. Lucas, of the National Museum, has determined to be that of a mastodon, probably *Mastodon americanus*, and certainly of Pleistocene age.

East of Newport, on the road to Toledo, the Pleistocene deposits form the surface of the approximately level country (peneplain) for about 2 miles, attaining an elevation of 350 feet above the sea level. They appear to have their greatest development close to the mouth of Yaquina Bay; to the northward, along the coast beyond Cape Foulweather, they are not well exposed. The character of the Pleistocene deposits about Yaquina Bay indicates that at least the lower portion of the deposit was beneath the sea, otherwise it could not include such abundant evidence of marine life and yet be free from indications of human accumulation. Concerning the overlying sands, containing the mastodon tooth and cones, the evidence is not so clear. Certainly land was close by. In the case of the gravels, especially those near the mouth of Nye Creek, their distribution suggests that they represent streams wandering over sand flats to the sea. We see the same sort of deposits at many places along sandy beaches to-day where small streams enter the sea.

Going now to the Coos Bay region, we find similar deposits, but not so well exposed as about Yaquina Bay. Southwest of Empire, at Fossil Point, by the mouth of South Slough, a series of soft beds 14 feet in thickness overlie Fossil Rock, as shown in fig. 7. They are chiefly sand, and no fossils nor conspicuous marks of stratification were observed in it.

Elsewhere about Coos Bay the Pleistocene is either absent, very thin, or not well exposed. Farther southward, however, there are several exposures in the valley of the Coquille. One of the best is along the railroad 2 miles northwest of Coquille, where, in a bluff 30 feet high, there is a fine outcrop of well-stratified sands. The summit of the exposure is at least 50 feet above the sea.

If now we take a general view of the Pleistocene deposits along the coast, it is evident that when these were laid down by the sea the place they now occupy was covered by the ocean, and the land along the coast must have stood at a lower level than at present. The amount of this depression is indicated by the height of the deposits above the present sea level. As far as may be judged from what is already known of the Pleistocene along the coast of Oregon, the depression was at least 200 feet, and probably much more. Our lack of knowledge concerning the upper limit reached by the water upon the ocean side of the Coast Range during the Pleistocene is due to the difficulty of discovering the record, on account of the dense forests and soft rocks, and also in a large measure to the very limited observations that can be made during a hasty reconnaissance through such a country.

It gives me much pleasure to call attention, in this place, to the work of Prof. Thomas Condon, the veteran geologist of the Northwest, who was formerly State geologist of Oregon, and who has contributed more than any other man to what is known of the geology of that State. He has traced the Pleistocene deposits from the mouth of the Columbia, not only north to beyond Shoalwater Bay, but also eastward far up the Columbia and into Willamette Valley, where he named the water body in which these sediments were laid down "Willamette Sound."[1] In some of the bluffs along the coast of Washington, Professor Condon has "found masses of buried forest trees, trunks, leaves, and seeds, so buried in clay, and so well preserved, that the spruce cone, fragile at all times, is scarcely discernible from one of last year's fruitage drifting in the neighboring waters. From these vegetal remains, as from those of the shellfish, the same truths are taught, for the trees are the same in kind as those now growing on the bluffs 100 feet above them." Of the marine shells found in these strata, Professor Condon remarks:

> The oyster is very abundant among them, and the shells of most of them are neither broken apart nor waterworn, as they would have been had they drifted here from some other locality. They evidently lie here as fossils, on the same bed they occupied while living; oysters then, as now, rarely bed in waters more than a few feet in depth. The common cockerel—another lover of shoal water—is also abundant among these remains, and, like the oyster, lies fossil where it lived; the opposite valves often now occupying the very positions relatively that they held while living, so, too, with the members of the clam family, whether mactra, or solen, or venus—all are evidently in their native beds, where they lived and died.

The thickness of these deposits, which at Ilwaco, as before stated, is only 14 feet, at some points on the beach farther north is 100 feet. The upper layers have the finest material and fewest fossils, indicating, as pointed out by Professor Condon, that the land was subsiding while

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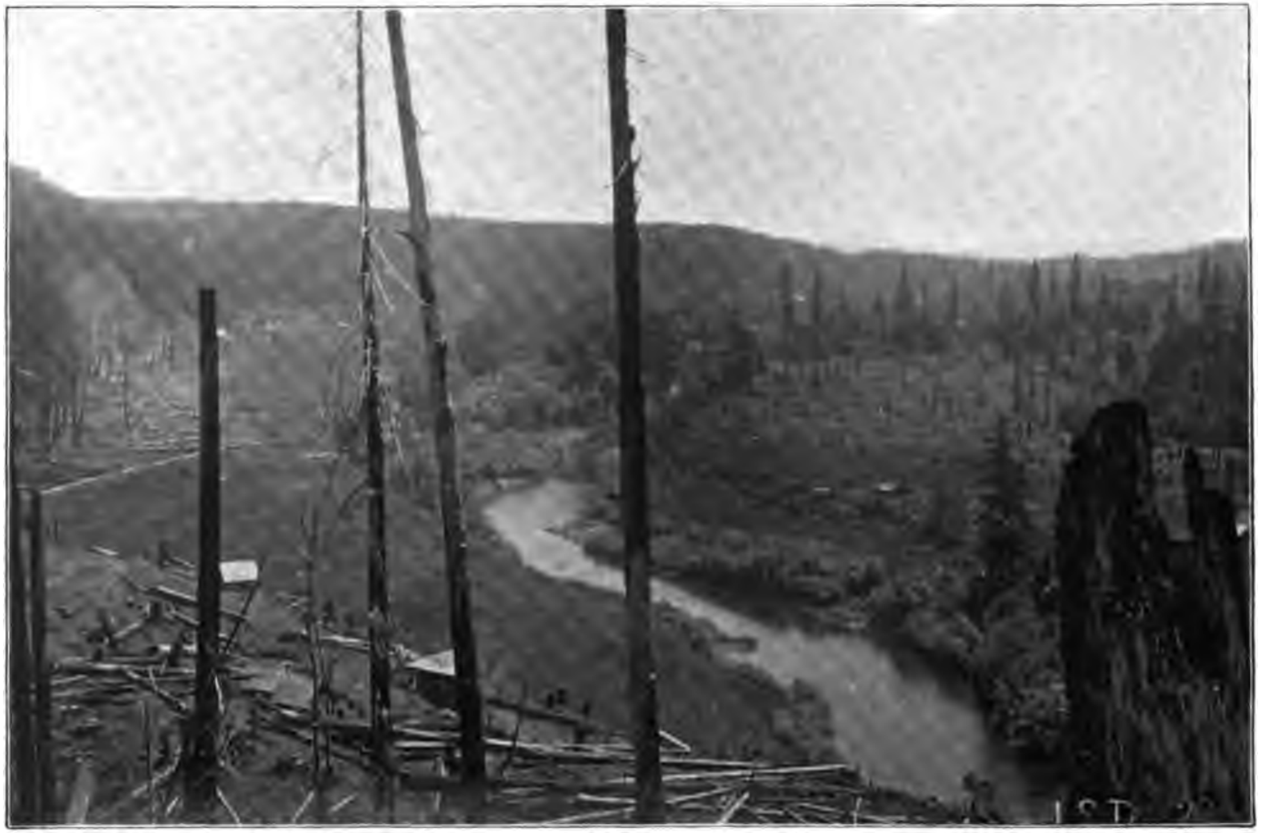
[1] The Overland Monthly, Vol. VII, pp. 468-473.



VIEW LOOKING SOUTHEAST FROM 2 MILES BELOW MIST, ON THE NEHALEM RIVER.

deposition was progressing, and that the final deposits were laid down in the deepest and quietest waters. At that time the topmost bed of this deposit was at a considerable distance below the level of the sea, at least 200 feet below the present level of that bed on the land.

If the whole of western Oregon subsided 200 feet in all parts, so as to restore at least in some measure the conditions of land and sea which obtained during the Pleistocene epoch, it is evident that the sea would flow in over the land, making a large bay of the Columbia and extending up the valley of the Willamette as far as Salem. The Pleistocene water body in its general outlines must have resembled Puget Sound, and to designate it specifically, as already indicated, Professor Condon called it Willamette Sound. The fertility of the Willamette Valley is largely due to the sediments deposited in it during the time it was a sound, and some of the plains and prairies may then have been formed.

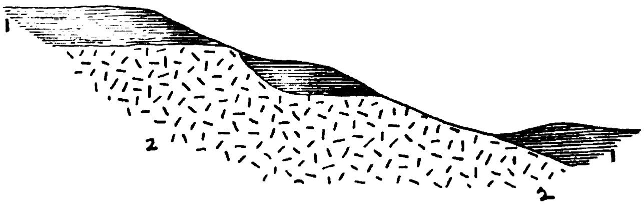


FIG. 15.—Section of Portland Heights near Gambrinus ravine. 1, Clay; 2. Basalt.

The data for the accurate determination of the depth of the water in Willamette Valley have not yet been fully made out, but the evidence already known to Professor Condon indicates that the water extended as far south as Spencers Butte, 3 miles from Eugene. Judging from the height of the terraces on the Columbia near the mouth of the Des Chutes, he estimated the depth of the water over the place where the city of Portland now stands to have been 325 feet. This may well be, and yet when we study the deposits of which the hills about Portland are composed a much greater depth of water is indicated. During a brief stay in Portland a rough section was made up the slopes of the ravine from Gambrinus. It is illustrated by fig. 15. The city is largely upon the modern flood plain of the river, and is, at least at a number of points—for example, on Washington street, near the Oregonian Building—made up chiefly of clay. The lower portion of the hill, above the general level of the city, is made up of basalt, with occasional masses of fine sediments, showing traces of stratification. The upper portion of the hill, extending from the top of the lava, at an elevation of about 310 feet, to the general plain above, which is at an elevation of nearly 660 feet above the sea, is fine, argillaceous sediment closely resembling the loess of the Mississippi Valley. It is in places distinctly stratified and was evidently laid down under water. If this material was deposited in the Willamette Sound of Condon, as appears to be the case, the depth of the water at Portland must have been not less than 600 feet. At present too little is known of the geology of the Portland region to assert that the fine sediments on the heights immediately west of Portland were deposited at the same time as those along the coast.

At the north end of East Portland, near Albino, a bluff exposes the section shown in fig. 16.

The 40 feet of coarse sand above is well stratified, but irregular and cross bedded. This, with the 4 to 10 feet of conglomerate next below, indicates strong, shifting currents. The lower 30 feet of the exposure is made up of sand, pebbles, and bowlders irregularly intermingled. At the base of the cliff, and occasionally within it, are found bowlders of soft gray or yellowish sandstone, very like the Tertiary sandstone exposed at various places in western Oregon. No fossils were found at this point, but Dr. David Raffety gave me a fragment, collected from the gravel at Brooklyn Mills, that contains *Arca microdonta* Conr., a common Miocene form. Brooklyn Mills is at the south end of East Portland. The bluff, in general composition and position, is practically a continuation of the one at Albino. The fossils found at Brooklyn Mills are apparently in a small bowlder derived from the Miocene, and indicate that the gravels in which the bowlders occur are of later age than the Miocene. They are doubtless Pleistocene, and probably younger than the high-level sediments on the opposite side of the river. The fossiliferous Miocene in place is not known to the writer nearer Portland than the Scappoose, in Columbia County, or Dilley, in Washington County, about 25 miles away. It is probable, however, that the same series of strata occur at no great distance south of Portland, and in the Willamette Valley[1] and in the hills to the westward, and, furthermore, they probably extend beneath the city, where they are covered by later deposits.

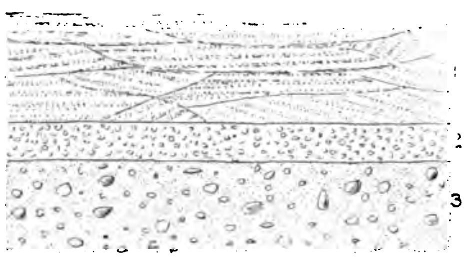


FIG. 16.—Section of cliff at Albino, near Portland. 1, Sand; 2, Coarse gravel; 3, Sand, pebbles, and small bowlders.

At various places along the western side of the Willamette Valley, between Forest Grove and Corvallis, a number of bowlders of granite and schist were observed under conditions that strongly suggest transportation by ice, probably in the form of icebergs, floating upon the Willamette Sound.

The first one noted was upon the hill slope near the county stone quarry, a mile south of Dilley, at an elevation of 120 feet above the sea. The bowlder is of biotite granite, and is about 2½ feet in diameter. Chloritic bowlders were seen near Amity, at an elevation of 190 feet. A few miles north of Corvallis granite bowlders occur, and 12

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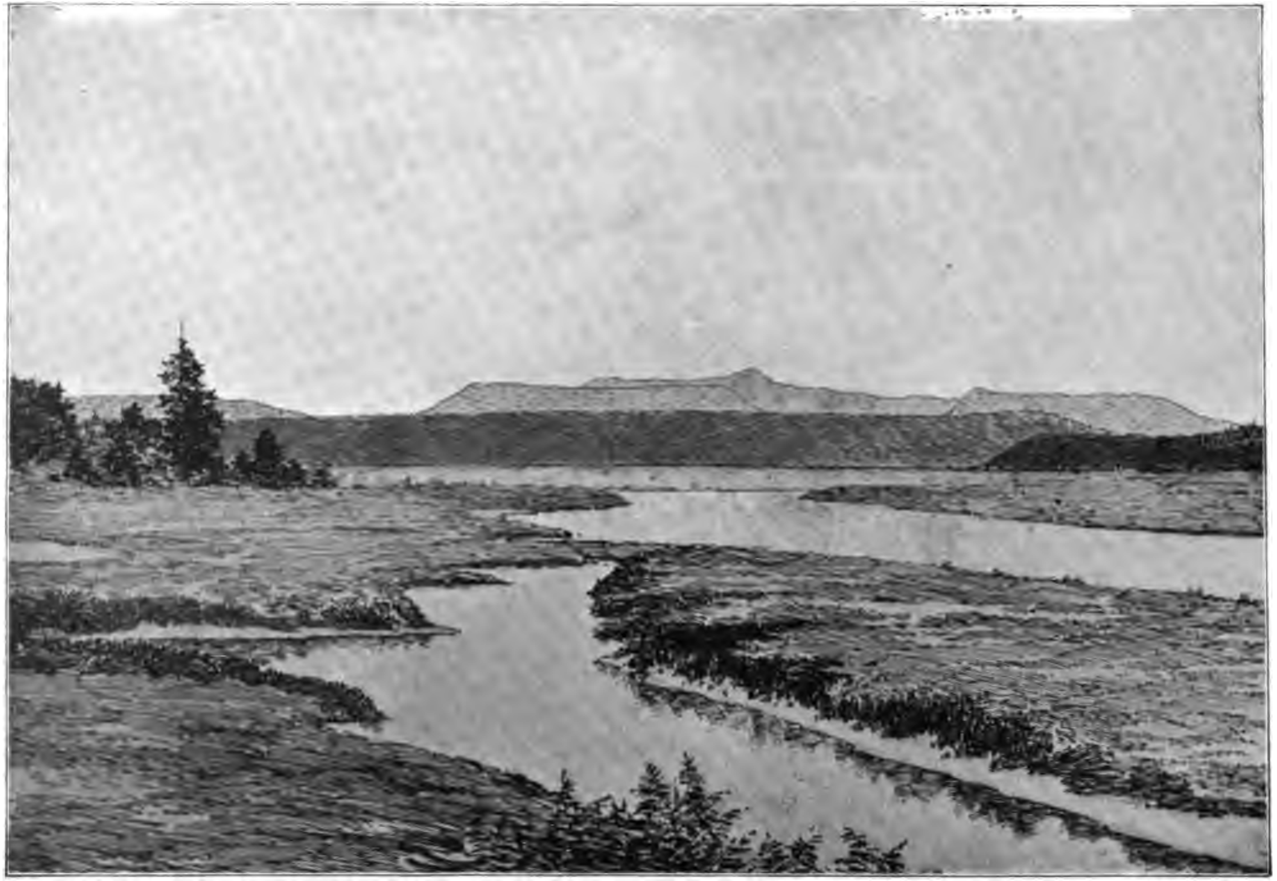
[1] In the Trans. St. Louis Acad. Sci., Vol. I, 1860, p. 121, Shumard describes a Miocene Leda from a few miles south of Oregon City.



VIEW LOOKING TOWARD SADDLE MOUNTAIN FROM YOUNGS RIVER BELOW OLNEY.

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miles southwest of that city bowlders, not only of granite but also of glaucophane schist, were seen by the roadside at an elevation of over 250 feet above sea level. No striæ or other marks showing glacial origin or ice transportation were seen on the bowlders, but that they are erratics carried there from the mountains is evident, for no such rocks are known in the places where they occur. Mr. W. A. Pomeroy, of Oswego, Oreg., informs me that in the vicinity of the Prosser mine, 8 miles south of Portland, there are angular bowlders of syenite, ranging in weight from a few pounds to several hundred, widely scattered in valleys and on the tops of hills and knolls 800 to 1,500 feet high.

During the Glacial period, as pointed out by Professors Newberry, Russell, and others, glaciers of the Cascade Range were large, and extended almost if not quite into Willamette Valley; for those of Mount Shasta in California at that time reached the very base of the mountain upon the western side. Thus small icebergs could have been readily formed to carry bowlders of rocks from the western slope of the Cascade Range and float upon the broad expanse of Willamette Sound. As they melted they dropped their loads of stones to the bottom, where the stones now appear scattered throughout the valley.

Hitherto in the consideration of the Pleistocene of Oregon, attention has been confined to matters growing out of the sediments deposited at that time. There is, however, another point of view. and that is from the land surface which furnished the sediments.

The streams flowing over the land, especially during freshets, carry much mud, sand, and other detritus into the sea, where it is deposited. Thus it is that the land is gradually being washed away and reduced in elevation toward the sea level. The level of the sea is the baselevel, lower than which the land can not be eroded. Practically it is only possible to reduce the land by erosion to peneplain (almost a plain), which is nearly at the level of the sea. By this process the mountains are gradually worn down to hills and then reduced to knolls, so that the landscape ultimately becomes a gently undulating plain.

To remove mountains and reduce the country to a peneplain by the slow process of erosion, requires that the land and sea should remain in the same relative position for a long time. The development of the peneplain begins along the principal water courses, where the erosion is most rapid and first reaches approximately the baselevel of erosion. Thence, as long as the land does not change its elevation with reference to the sea, the peneplain will gradually spread, and, unless interrupted, will extend until it embraces the whole landscape.

A glance at the Coast Range of Oregon, which this reconnaissance afforded, discovers traces of peneplains at many points throughout the range. Such a plain may be seen in the general view looking north from Forest Grove, where, as shown in Pl. XII, the long, even profile of the divide, about the head of Gales and Dairy creeks, is well marked. From an outlook to the west and southwest, immediately above Boos's rock quarry, 5 miles southwest of Forest Grove, a well-marked peneplain is seen. Flat-topped Quarry Hill is in the plain, and has an elevation of about 525 feet above the sea, and from this point the peneplain rises westward toward the central portion of the Coast Range. The Tualitin, on its way to the Willamette, has cut a deep valley across this plain. At the quarry Miocene fossils are abundant, and the sandstones dip at an angle of 34°, so that the plain is evidently one of erosion across the upturned edges of the Miocene. The formation of the peneplain was not complete, for there are peaks and ridges which project above its general level. Adopting the general term "monadnocks," first used by Prof. W. M. Davis to designate such well-marked elevations as project above the peneplains, it may be said that monadnocks are not an uncommon feature in the northern portion of the Coast Range, and that the peneplain terminates against them quite abruptly.

The dense forest covering throughout the Coast Range renders extensive views uncommon, but wherever obtained traces of an elevated peneplain may generally be seen. This is especially true about the northern portion of the Coast Range in Oregon. A general view toward the southeast from near Mist, with the Nehalem River in the foreground, is shown in Pl. XIII. A portion of an elevated peneplain appears at the head of the valley.

The uplands, excepting monadnocks, are generally flat-topped, and the peneplain of which they form a part is highest near the middle of the range. Along the Military road, now a trail, reaching from Mishawaka to Saddle Mountain and beyond, the peneplain is marked. It ranges in altitude from 1,250 feet near the falls of the Fish Hawk to about 1,700 feet near Saddle Mountain, which rises above the general plain as a distinct monadnock. Its relation may best be seen from a point several miles northwest of Olney, where the following view (Pl. XIV) was taken. The highest point is Saddle Mountain. It rises conspicuously above the general plain, which is shown on the flat-topped hills next nearer to the point of view. These represent the highest peneplains, ranging from 1,200 to 1,700 feet. Immediately north of Olney there is a well-developed plain cut upon the upturned edges of the shales at an elevation of about 400 feet. This plain is of considerable extent to the north and east of Olney, and next below it, several miles farther down the river, is a plain only 50 feet above the tidal flats. The relations of these plains to one another, whether they are simply parts of one great plain separated and displaced by faulting or entirely distinct plains developed at different periods, have not been definitely determined, although the facts observed indicate that the latter view is correct.

The peneplains already noted about the northern end of the range may be traced more or less distinctly to the southward, but on the whole they are generally less marked. There can be no doubt, however, concerning their reality and the light they throw upon the later

VIEW LOOKING SOUTHEAST ACROSS THE NEHALEM FROM 2 MILES BELOW NEHALEM POST-OFFICE.

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geological history of the Oregon coast. In a view (Pl. XV), looking southeast across the river from a point about 2 miles below Nehalem post-office, the even-topped hills may be seen bristling with dead timber, and the distant mountains as monadnocks projecting above the general level of the peneplain. A similar view (Pl. XVI) is obtained from Toledo, looking across the Yaquina River. The distant monadnocks are absent, but the all too frequent bristling hills are especially well shown.

The streams of the Coast Range at the present time cut deep canyons down its slopes, and it is evident that the peneplains of that region could not have developed at their present elevation above the sea. At the time of their origin each must have been but little above the level of the sea, and since then, by the upheaval of the land, they were raised to their present position. A very rough approximation as to the amount of the upheaval is given in the measure of their present altitude. The greatest elevation of the plain observed was 1,700 feet. It may, however, attain a greater altitude. About the head of the Klatskanie very suggestive level tracts were noted on the road from Pittsburg to St. Helens, on the west side of the divide, at an elevation of over 2,000 feet. Some of the flat tops in that region, however, are due to lava cappings, and the surface beneath may not be so regular. The uplift may have been greater in some places than in others, but of this the evidence is not conclusive, as there may have been considerable differences originally in the elevation of the higher and lower portions of the peneplains.

The upper peneplain is cut upon soft sandstone and shale, and the structure is such as to suggest that only a comparatively small mass of these soft strata was worn away in forming the peneplain. These features indicate that the work was accomplished in a relatively short time, and that the resulting deposits along the coast were of comparatively small amount, although it is believed that other deposits of Post-Miocene strata may yet be discovered upon the slopes of the Coast Range.

At the time of the greatest depression, when the most extensive peneplain was developed, the Nehalem and the Umpqua rivers may have initiated their courses across the Coast Range and maintained them, notwithstanding the upheaval of the Coast Range across their valleys. If so, they were able to cut their canyons across the range as rapidly as the elevation required them to do in order to drain directly across the range.

As the land was raised from the conditions under which the peneplain was formed, the retiring ocean, in favorable positions at various levels, left its marks as wave-cut terraces or elevated beaches, with sea cliff and shells and other deposits. River terraces, well developed along the Nehalem and other streams, record stages in the progress of valley making.

The soft sandstone and shales of the Miocene are not well suited to preserve such records upon steep slopes, although they may be observed at a number of places. The peneplain at the 400-foot level, southeast of Astoria, is well marked, and at other points along the coast traces of beaches and terraces were seen most frequently about that elevation above the sea, although in most cases no attempt was made to more than roughly estimate their altitude. A well-marked peneplain about this elevation is the dominant topographic feature between South Slough and the sea near Coos Bay. A good view of it is obtained on the road from Empire to Bandon, and near the edge of this peneplain, especially toward the Coquille, there are important deposits of auriferous black sand. It is possible that at about that level the previously raised land stood still for a time, allowing the erosive agents to make a deeper record. But if it halted at all in its upward course it did not stop long at any level, and the upward movement continued until the land was raised above its present position.

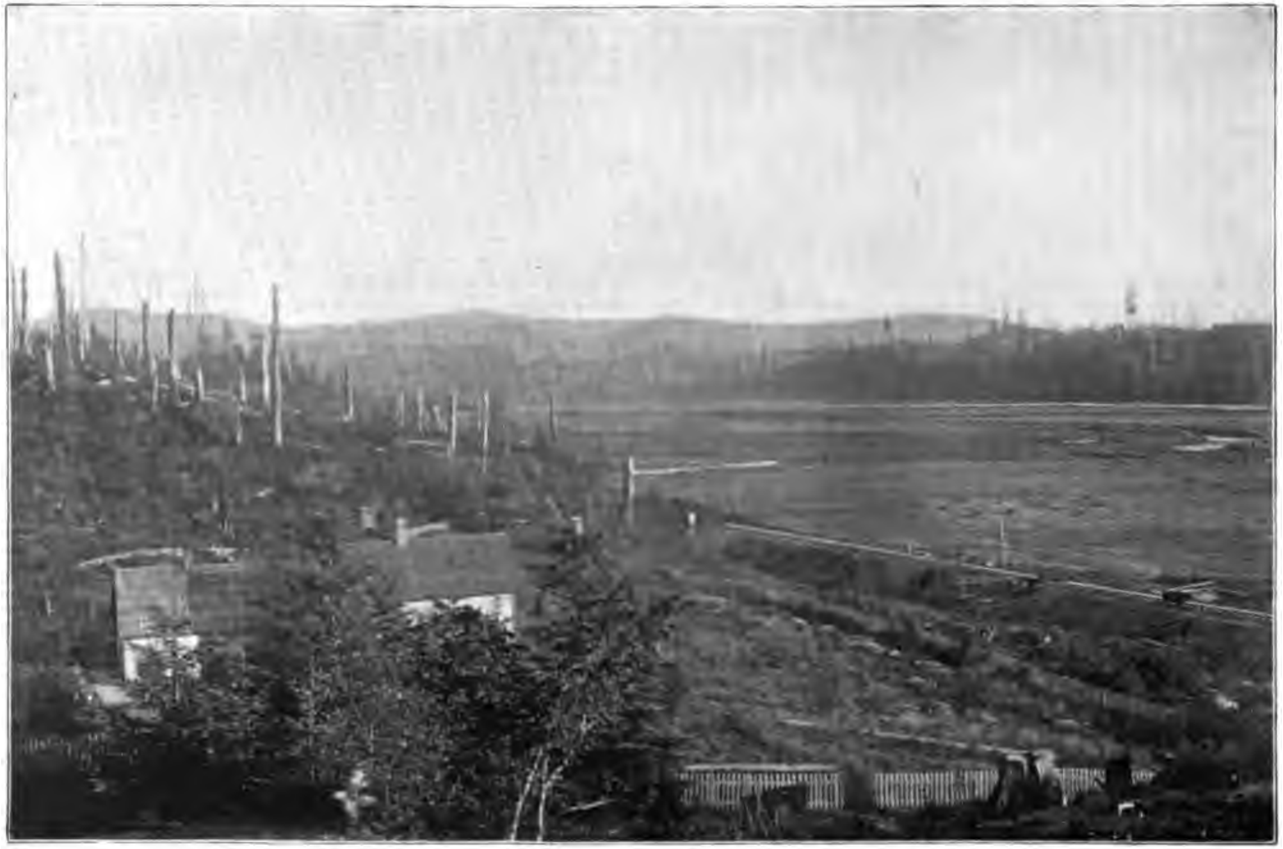
At that time the coast of Oregon was farther westward, and the land included a strip about 5 miles in width that now lies beneath the ocean. Across this border the rivers once flowed and cut channels to the sea. The numerous soundings made by the United States Coast and Geodetic Survey along the coast of Oregon show that an old channel of the Columbia still exists beneath the sea from the present mouth of the river to a point where the bottom falls off rapidly and the deep sea begins. My information upon this point was derived from Prof. George Davidson, who for many years had charge of the work on the Pacific Coast.

The last movement of the land by which the Oregon coast came to its present position was one of subsidence. The sea advanced over the land, and the border of the coast already referred to became part of the bottom. This movement had a marked effect upon the rivers. They are drowned on the lower portion of their courses, and the tide comes far inland. In the case of the Coquille the tide follows up the river to Myrtle Point, a distance of 40 miles.

PART II.

ECONOMIC GEOLOGY.

Having considered the region embraced within the reconnaissance with reference to its geological structure and history, we can now more intelligently turn our attention to the deposits of economic importance associated with the various formations. The coal fields will be first described, and then the occurrence of iron ore, gold, platinum, and building stones will be briefly considered.



VIEW FROM TOLEDO, LOOKING ACROSS THE YAQUINA.

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THE COAL FIELDS OF WESTERN OREGON.

Oregon has long been known as one of the coal-producing States of the Pacific Coast, but until this season no systematic attempt has been made to take a comprehensive view of the whole field to determine the geological position and areal distribution of the coal-bearing rocks. This could be done at the present time only in a preliminary way, inasmuch as the topographic maps of the country, upon which the productive districts could be outlined, have not yet been made. When the topographic surveys, already well advanced about Roseburg and Coos Bay, shall have been extended over the whole of Oregon west of the Cascade Range, and the maps published, it will be possible to show definitely the lateral extent of the coal regions.

The coal fields of Oregon so far as yet known all lie west of the Cascade Range and north of Rogue River. Most of them are among the mountains generally known in Oregon as the Coast Range, but others occur at the western foot of the Cascade Range. Four fields will be noticed here: (1) The Upper Nehalem coal field, in Columbia County; (2) the Lower Nehalem coal field, in Clatsop County; (3) the Yaquina coal field, in Lincoln County; and (4) the Coos Bay coal field, in Coos County. Traces of coal have been found in many other parts of the State, and some of these occurrences will be noted, although little can be said concerning their extent. It is not at all improbable, however, that when the detailed explorations of the Geological Survey are made other fields of considerable size will be discovered. Such explorations are necessarily slow. The luxuriance of the undergrowth, especially near the streams, and the abundance of fallen timber render the forest in many places upon the upland slopes of the Coast Range a veritable jungle. Exposures are few and meager and their rarity greatly increases the difficulties which beset the geological observer.

THE UPPER NEHALEM COAL FIELD.

The Upper Nehalem coal field is in Columbia County, within the drainage of the upper portion of the Nehalem River. It extends northeast and southwest a total length of about 13 miles, and has a width of 1 to 2 miles. The coal of this field is exposed upon the forks of Pebble Creek, the east fork of the Nehalem, and the Clatskanie.

Beginning at the southwest end of the field, in sec. 34, T. 4 N., R. 4 W., there is a bed of coal which has been opened in the main fork of Pebble Creek near the county line. The pit, which once exposed the whole thickness of the bed, had been filled up by the stream, but I was informed by Mr. N. C. Adams, who prospected much of the coal in that region, that the bed is 4 feet 10 inches thick, including a parting of soft yellowish sandstone which measured 4 to 6 inches. At the time of our visit only the upper 18 inches of the bed could be seen.

On a fresh fracture the luster of this coal is brilliant, but soon becomes dull. It has a fine-banded structure parallel to the bedding, and upon exposure to changes of temperature and moisture fissures develop along these planes in the coal, but much of it does not slack. It contains a few nodules of pyrites, breaks readily into flattish pieces, and burns with a bright yellow flame. Analyses numbered 2 and 3 in the table given later are of coal from this locality.

The coal lies between sandstones. In the gray sandstone above, Mr. F. M. Anderson, who assisted me in the examination of nearly all the coal fields, collected a few fossil shells and fish scales. The sandstone is occasionally hard, but not so firm throughout as to make timbering entirely unnecessary in mining the coal.

About 100 yards farther down Pebble Creek, upon the right bank above the stream, apparently the same coal crops out, showing that the strata dip gently eastward.

The best exposure of the coal seen in this field is upon the East Fork of Pebble Creek, in section 23, where the Great Northern Coal Company has opened several drifts along the croppings of the principal coal bed. From any elevated position affording a good general view of the upper portion of the Nehalem Valley, it may be seen that the streams all flow in canyons cut in the broad upland platform, which is almost a plain—a peneplain. The general level of this peneplain bordering the canyon of the East Fork of Pebble Creek is from 1,250 to 1,340 feet above sea level. The canyon in section 23 has a depth of 420 feet, and the steep slopes of its lateral gulches afford some good exposures of the coal beds and associated sandstones.

Nearly midway down the western slope of the canyon, at an elevation of 1,050 feet, two small coal beds occur. The upper contains about 12 inches and the lower 14 inches of impure, dull, platy coal. The beds are 10 feet apart, and both are inclosed in soft sandstone.

Fifty feet lower upon the side of the canyon, and a short distance farther up the stream, are three tunnels, run in a few years ago by the Great Northern Coal Company upon a bed of coal nearly 9 feet in thickness. The longest tunnel follows the bed about 100 feet, and affords a fine exposure of the coal. The coal is generally compact and fine-banded, splitting most readily parallel to the bedding. Near the bottom of the bed the woody structure of the lignite is well preserved. On a fresh fracture the luster is often brilliant, but, with the exception of occasional thin, irregular bands, it soon becomes dull-brown, and upon exposure falls to pieces more or less readily. It lies between beds of rather soft sandstone, which may in places be firm enough to support the roof without timbering. The coal dips gently to the southeast, and a large portion of it lies above drainage, so as to be economically mined. The canyon would afford an easy line for a railroad to the Nehalem River, along which the easiest grade for a railroad toward the coast could be obtained.

Eighty feet below the tunnel already mentioned, by a stream at the bottom of the canyon, another bed of coal crops out. It is from 6 to 8 feet in thickness, contains several sandstone partings, and is overlain by soft sandstone. The quality of the coal is much the same as that in the larger vein above. It has been prospected by the Great Northern Coal Company, but for only a few feet beneath the surface. This bed is inclined at an angle of about 10° in a direction between south and southeast.

About one-third of a mile northeast of this locality, in the next gulch, two beds of coal appear. The upper bed is about 10 feet in thickness, but it is impure below and contains two sandstone partings. Farther down the same gulch is an 18-inch coal, and near it occur numerous fossils similar to those found in the same bed at the lower drift of the Great Northern Coal Company. They resemble the fossils which occur close to the coal in section 34.

Analyses 4, 5, and 6, in the table given later, are of the coal on the East Fork of Pebble Creek. The coals contain an unusually large percentage of ash and sulphur. Fearing that there was some mistake, these determinations were made again, with practically the same result.

The position of the strata on Pebble Creek and the East Fork of Pebble Creek suggests that the coal in section 34 is probably continuous with that in section 23. If so, it should crop out in the ravines in section 27 and the adjacent corners of sections 22 and 26. This view is supported by the fact that the Eocene fossils at the two localities are clearly related, and yet the striking differences in chemical composition tend to show that the beds are distinct.

The thickness of the beds is sufficient to suggest considerable lateral extension, and for this reason the same coal might be expected to appear upon the East Fork of the Nehalem River. In fact, two coal beds have been discovered upon one of the forks of that stream. Mr. A. H. Powell has prospected them in sec. 27, T. 5 N., R. 3 W. At this point the general elevation of the peneplain is about 2,200 feet, and the canyon is over 400 feet deep. The coal is about 5 feet in thickness, and lies between horizontal beds of sandstone. It is shaly, and, judging from its looks alone, appears to be inferior in quality to that of the East Fork of Pebble Creek.

Mr. Powell reports a bed of coal farther down the ravine, about 80 feet below the one just noted, and smaller beds farther up, but on account of landslides, the luxuriant undergrowth, and a large amount of fallen timber we were unable to find them.

Mr. Anderson collected a number of fossil shells near the coal, and it was then thought probable that the same bed continues from sec. 34, T. 4 N., R. 4 W. to sec. 27, T. 5 N., R. 3 W., a distance of nearly 10 miles. According to Dr. Dall, the fossils do not support this view, for in section 37 the shells are apparently of Miocene age, while these of sections 34 and 23 are unquestionably Eocene. So far as the writer is aware, no coal has yet been found on the main stream of the East Fork of the Nehalem, where it ought to be exposed if continuous, as suggested above. In that locality it would be more conveniently located for shipment to the main valley of the Nehalem and the coast.

Fragments of coal have been found on the Clatskanie, showing that the coal beds occur within its drainage. It is most probable that they outcrop near the head of the stream, where it is nearest the coal on the East Fork of the Nehalem.

The upper Nehalem coal field, while it has a length of over 10 miles, is, as far as yet known, not over 2 miles in width, so that the whole area of the field is less than 20 square miles. Nevertheless, with two beds of coal, one 6 and the other 9 feet in thickness, it ought to yield a quantity of coal of commercial importance, if upon practical tests the coal is proved to be good enough to create a demand for it, and if facilities are provided for cheap transportation. At present the best outcrops are not reached by even a poor road.

About a ton of coal from the East Fork of Pebble Creek was packed out and sent to Portland, where it is said to have burned well in stoves, but, so far as the writer knows, its steam producing power has never been measured.

LOWER NEHALEM COAL FIELD.

The Lower Nehalem coal field is situated north of the Nehalem, near the county line between Clatsop and Tillamook.

In sec. 16, T. 3 N., R. 10 W., occurs an 18-inch bed of coal lying between beds of clay. It is near the south foot of Ne ah kah nie Mountain, and is inclined at an angle of 30° southwestward. A short distance farther down the slope is another exposure of coal. It can be traced for 50 feet along the strike and ranges from 5 inches to 14 inches in thickness. It dips at an angle of 30° to the northwest, nearly at right angles to that in the other exposure. There may be two beds of coal here, but considering the softness of the associated strata and the difference in position of the coal outcrops, it is not improbable that the lower exposure is only a slide from the upper. The analysis of coal from this locality is No. 11 in the list.

On another branch of Hodge Creek, about 250 yards to the eastward from the locality just noted, two tunnels have been driven by Mr. J. G. Gerritze for Mr. S. F. Pearson. In one of them a 2-foot pocket of brilliant, homogenous, fine-looking coal was found, which yielded the analysis No. 12 in the table.

On Coal Creek, in sec. 2, T. 3 N., R. 10 W., is an 18 inch bed of coal which lies between shales and strikes northeast and southwest, dipping to the northwest at an angle of 50°. The coal resembles that from section 16, of which it may be a continuation, for a coal of the same character, 22 inches in thickness, is reported by Mr. Frank Steinhäuer from section 10, which lies between, and a similar if not identical lustrous, black 10-inch coal occurs in section 36 of the next township to the north. It lies between sandstone (above) and shale. Analysis No. 13 shows its composition.

No fossils were found in immediate connection with the coal, so that its age is not definitely known, but it appears to be beneath the Tertiary shales exposed near Crawford on the North Fork of the Nehalem.

Sections 16, 10, 2, and 36 are all in a line extending northeast and southwest, and the coal exposed in them may all belong to the same bed. The coal field, so far as known, has a length of about 5 miles. The quality of the coal is good, but its thickness, so far as yet known, nowhere exceeds 22 inches. It occurs in strata so soft as to render timbering generally necessary, and is inclined at a considerable angle. In view of these facts, notwithstanding its good quality and nearness to tide water, above which it rises only a few hundred feet, it can not be regarded as promising commercial importance.

THE YAQUINA COAL FIELD.

This field is in Lincoln County, north of the Yaquina River, and 6 miles from the coast. It borders Depot Slough upon the west, and has its greatest extent north and south.

A few miles west of Toledo, in sec. 13, T. 11 S., R. 11 W., coal has been found in a number of gulches. At one place the coal is exposed in a tunnel nearly 200 feet in length. It is greatly fissured, and the cracks contain a yellowish coating that makes the coal look muddy. The bed at the end of the tunnel is about 20 inches in thickness. It becomes thinner to the northwest, as the bottom rises in that direction, and it lies between soft sandstones, the top one of which contains marine shells. The inclination of the strata was not accurately measured, but it has been estimated at 20 degrees. Analysis No. 14 is of coal from this locality.

Dr. J. H. Bryant, who systematically prospected this field with a diamond drill, bored a hole a short distance southeast of the tunnel, but I have not yet been informed what he found. In this same neighborhood there are other exposures of coal, but so far as yet known they are small and of no value. In places the sandstones contain many small films or lenses of coal, and there are all grades in size from this to beds 20 inches in thickness and a mile or more in lateral extent. The character of the deposits everywhere, not only in this field, but in others, is such as to indicate that they are very local and in most cases not of commercial importance.

In sections 36 and 30 of the next two townships to the north several outcrops of coal have recently been prospected with the diamond drill by Dr. J. H. Bryant. One bed having a thin parting of sand is reported to average 3 feet of coal. A sample from this bed was given me by Mr. P. T. Johnson. Its composition is numbered 15 in the list of analyses. The extent of this coal is not yet known, but it is not believed to be great.

Farther northward traces of coal have been found near the head of Depot Slough, and also on the Siletz River, but the outcrops are less promising than those already noted.

The Yaquina coal field has a length from north to south of about 5 miles and a breadth of not over a mile. It contains, apparently, several beds of coal which belong to nearly the same horizon. Although not very far from marine transportation, it does not promise to be of great commercial importance.[1]

THE COOS BAY COAL FIELD.

The Coos Bay coal field is the most important one in the State, and when thoroughly mapped will be a subject for later report. Thus far only a general reconnaissance has been made for this preliminary report and comparison with the other fields.

It is situated in Coos County, upon the borders of Coos Bay, with a length northeast and southwest of at least 20 miles and a breadth of 5 miles, so that its area is not less than 100 square miles. It is probable that future investigations may show this field to be considerably larger, but at present no promising outcrop is known to the writer south of the latitude of Bandon or north of Haynes Slough.

At the southwestern end of the field, near Riverton, a 3½-foot bed of coal has been opened by T. H. Timon. The writer's information concerning this coal has been derived from Mr. Timon, and from Mr. E. C. Barnard, of the United States Geological Survey, who examined the mine. A tunnel is driven in the coal for several hundred feet. Mr. Timon estimated the output for 1895 at 4,000 tons. It is said to be good steam coal. The bed is only about 100 feet above the tide water, one-fourth of a mile away, and dips to the northeast at an angle of about 18°. The coal is overlain by sandstone, has a small parting of the same material, and rests upon shale. The compact character of the coal permits it to be mined in large fragments. Its analysis, from a sample furnished by Mr. Timon, is No. 17 in the table. The good quality of the coal and the economy with which it can be mined and shipped, combine to render this a promising portion of the field. The shallow bar at the mouth of the Coquille is, however, a serious impediment to commerce. Mr. Timon says that there are a number of persons prospecting for coal in that region, and that several other veins will be worked when the entrance to the Coquille is improved sufficiently to afford better freight rates.

Messrs. Fred. F. Sharpless and Horace V. Winchell examined the auriferous black sands and coal deposit in part of the country lying immediately north of the Coquille River. They report a bed of coal near Riverton with an average thickness of 33 inches. Its outcrop is about 100 feet above the river, and the dip of the bed is 8° to the northwest. It has been developed by an open pit and a tunnel about 20 feet in length. Sharpless and Winchell have made three analyses of this coal, and the results are numbered 18, 19, and 20 in the list.

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[1] Mr. John Ray, of Corvallis, has prospected for coal and collected numerous fossils in Benton County, and he has published two small papers, entitled "Hints on coal-bearing formations in Benton County" and "The older Coast Range." I desire to express my indebtedness to Mr. Ray for much valuable information concerning that region, especially as to the occurrence of fossils.

The dip of the strata on the Coquille near Lampers Landing is northward at an angle of 45°. They are full of fossils like those near Marshfield, and suggest that the coal of Iowa Slough, which overlies them, may be of the same horizon as that of the Newport mine.

Sharpless and Winchell report an important bed of coal about 4 miles northwest of Riverton, in sec. 23, T. 27 S., R. 14 W. Their report has not yet been published, but I have been permitted to read it, and make the following and other extracts:

> At this point a tunnel is found running into a hill for 150 feet on the strike of a coal seam. This coal bed has a thickness of at least 7 feet, and perhaps 9 or 10. Four feet of coal lies above a parting which is 4 inches thick, and 3 feet of it below this main parting. There is another shaly parting of 2 inches 3 feet above the main parting. The dip of this coal is east 25°, which would rapidly lead to a considerable depth in mining conditions. The hill rises about 100 feet above the tunnel, and could be easily drained for 50 or 75 feet below it. Other coal seams are said to occur in the same hill, but were not examined.

The analyses of this coal, furnished by Sharpless and Winchell, are numbered 21, 22, and 23 in the table.

Six miles north of Riverton and about 3½ miles northeast of the occurrence last described is the Beaver Hill mine, opened within a year, and now actively operated by R. A. Graham, with J. L. Parker as superintendent, and a large force of men. A branch of railroad 1½ miles in length has been built to it from the main line of the Coos Bay, Roseburg and Eastern Railroad near Coalton.

The bed is somewhat variable in thickness and contains two thin partings of sandstone. The associated sandstones between which the coal appears are sometimes fossiliferous and comparatively soft, although in many places firm enough to stand without timbering.

The coal is brilliant black, with homogeneous structure, and has the composition given under No. 24 of the table. The large force of men is employed chiefly in developing, and the mine has not yet entered fully upon its career as a producer. During 1895, 12,000 tons were shipped.

The strike of the bed varies considerably, but generally it is in a northeasterly-southwesterly direction, with a variable dip to the southeast at an angle of about 40°. The strata here are much disturbed, and the high angle at which they incline greatly increases the cost of mining the coal. Upon the surface the Beaver Hill bed has been traced along the strike for 8 or 10 miles.

The only coal mine of Oregon which has been continuously operated for a considerable time is the Newport. It has been worked for over forty years, and it owes its success not so much to the quality of the coal as to economical mining and management. It is now operated by Goodall, Perkins & Co., of San Francisco, with Mr. William Campbell as superintendent. The writer personally examined only one tunnel of the mine. All his information with reference to other portions of the mine and to the Newport basin was kindly furnished by Mr. Campbell. The location is in sec. 9, T. 26 S., R. 13 W., where a ravine has cut into the middle of the shallow basin containing the coal at an elevation of about 100 feet above sea level. The bed of coal is about 5 feet 8 inches in thickness, and has two small sandstone partings of 6 inches each, leaving 4 feet 8 inches of solid coal. The total thickness varies greatly from place to place, especially about the islands which the coal encircles within the basin. The coal appears to be contained in a shallow, boat-shaped fold, which, according to Mr. Campbell, is about 4 miles long and 1¼ miles broad. The coal is said to outcrop upon the surface around the edge of this synclinal basin (the Newport Basin), and toward its center the coal is covered by 100 feet of sandstone. The opening of the mine is in a gulch near the center of the basin. The coal appears to dip gently toward this point from all directions. A stationary engine upon the outcropping edge of the bed pulls the empty cars into the mine, and the loaded cars run from all parts of the mine to the opening by gravity. The slopes of the ravine in which the mine opens afford a convenient means for utilizing gravity as an aid in sifting, sorting, weighing, and loading the coal on the cars, which carry it by a comparatively gentle grade down Coal Slough to large bunkers on Coos Bay near Marshfield, where it is easily transferred to vessels. The position of the coal bed and its situation with reference to the sea are very important factors in the cheap production of coal from the Newport mine.

The coal of this mine is brilliant black, breaking into small cubical blocks. In some places it is homogeneous, and at others it is irregularly streaked parallel to the bedding plane. The character of the vegetation from which the coal originated is shown by the occurrence of logs, which are sometimes completely changed to coal, and yet the woody structure is fully preserved. An analysis of a piece of coal in which the woody structure is distinct is No. 25 of the table. A comparison of this analysis with the one numbered 26, which was made of coal selected by Mr. Campbell as a representative sample of the Newport mine, will show how completely the wood has been changed to coal. A comparison of these analyses with those numbered 27 and 28 shows an improvement in the quality of the coal. What is now mined contains considerably less moisture and sulphur than that analyzed by Mr. Price.

The bottom upon which the coal rests is chiefly sandstone, and it is occasionally quite irregular, sometimes rising into the coal and cutting it off completely. The coal encircles several small areas; these were small islands in the swamp in which the vegetation accumulated to form the coal. One of these islands is shown at the mouth of the mine near the center of the basin, where the coal runs out completely and the limiting sandstones come together with only dark tracings to mark the boundaries.

The outcropping coal about the edge of the Newport Basin shows that the swamp in which the coal originated was of greater extent than the basin. The swamp may have extended more or less continuously throughout the whole coal field from the Coquille to North Slough. The rocks at that time were lying horizontally. The Newport basin originated at the time the rocks were folded. The upward folds, or anticlines, were largely washed away, but the downward folds, the synclines or basins containing the coal, have been preserved. That the Newport coal is in a shallow syncline there seems to be no doubt from the testimony of the mine itself, for the coal is reported to have been sufficiently prospected or removed to expose the form of the fold. The structure of the remainder of the coal field has not yet been wrought out. The dips of 18° on the Coquille and 45° at the Beaver Hill mine show greater disturbance than at the Newport mine.

During the summer of 1895 there were only three mines in active operation, the Newport, the Beaver Hill, and the Timon. Others have been operated in the past, and some continued several years. The Eastport mine, immediately north of the Newport, according to Mr. W. A. Goodyear,[1] was active in 1876 and produced considerable coal. He reports as follows:

> The aggregate thickness of the coal mined ranges from 4 to 5 feet, averaging about 4½, in two benches of nearly equal thickness with a stratum of soft shale between them whose average thickness is about 6 inches, though it ranges in different parts of the mine from 4 to 10. Above the upper one of these two benches comes a stratum of shale, generally about 1 foot in thickness, and immediately over this again about 1 foot of coal [2]

The Newport mine is evidently on the same bed of coal as that formerly worked in the Eastport mine.

Mr. Goodyear reports a new mine in 1877, immediately south of the Newport mine. A tunnel was driven some 500 or 600 feet upon the coal bed.

> At a point where the tunnel was commenced there was no visible outcrop whatever of the coal at the surface of the ground, but a few feet beneath the surface a dark colored streak began to show itself, which grew rapidly thicker and purer until within 100 feet from the mouth of the tunnel it had developed into a bed of good coal about 4 feet thick. Beyond that point, as far as the tunnel has yet extended, this bed will furnish from 4 to 4½ feet of clean, hard coal, of a quality as good as the best hitherto furnished by the Coos Bay mines. The strike of the bed is about N. 18° E. true course, and its dip is about 8½° to the east. It has in the middle of it a streak an inch or two in thickness of soft clay "mining;" but the remainder of the bed is good, clean coal, which separates easily from the roof and floor, and as, furthermore, both roof and floor consist of good, solid sandstone, the coal can be mined from this bed for a little less cost than it can at either of the other mines, where the

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[1] The Coal Mines of the Western Coast of the United States, 1877.

[2] Loc. cit., p. 87.

roof is not so good. So far as can be judged from surface indications also, there is every probability that the mine will prove an extensive one, and that the quantity of the coal which can be cheaply extracted from it will be large.[1]

This mine closed some years ago for reasons unknown to the writer.

Five miles directly north of Marshfield and between North Slough and Jordan Point, or Kentuck Slough, is the Glasgow mine, which has been operated, and much money has been devoted to prospecting and developing it. The mine is not open now, but Mr. William Sharp informs me that there are two beds of coal, one 180 feet above the other, reached by separate tunnels. The upper bed has about 5 feet of coal, with two partings; while the lower bed has about 9 feet of coal, with four small partings. Mr. Goodyear examined this locality in 1872, when the Hardy mine was in operation. The strike of the bed of coal exposed in the long gangway was north and south, with a dip of 16° to 18° to the westward. Although the coal outcropping at the surface appears to be of fair quality, in the gangway below it was found to be soft, and crumbled very badly on exposure.

The bed itself is, in all probability, identical with the one in the Eastport and Newport mines, as it consists of the same three layers of coal with streaks of clay-rock between them, arranged in the same order, and preserving very nearly the same thickness, both relatively and absolutely, as at those mines.[2]

This bed, upon which the Hardy mine is located, is evidently the upper bed noted by Mr. Sharp.

In sec. 23, T. 26 S., R. 13 W., a few miles from the head of Isthmus Slough, the Utter mine was operated about twenty years ago, and produced, according to Mr. Utter, about 10,000 tons of coal. The coal bed is said to have been 6 feet in thickness, with a small parting of shale near the middle. The lower half of the coal is soft and of little value, but the upper half is of much better quality. The strike of the bed is nearly east and west, with a dip of 17° southward. On account of the quality of the coal and the cost of production and transportation the mine has been closed for years.

In the next section to the westward (22) the North Pacific Coal Company began operating apparently upon the same bed that occurs in the Utter mine, but with no better success.

Farther north, but upon the east bank of the Isthmus Slough, near the line between sections 34 and 35, T. 25 S., R. 13 W., a mine known as the Henryville mine was expensively opened and outfitted. The plant is now practically in ruins. An incline was driven for a distance of 1,000 feet or more at an angle to the dip, upon a thick bed containing much carbonaceous material, but without finding coal sufficient to pay for mining. At this point the strike of the strata is north and south and the dip easterly. The angle of the dip is greater and the beds are more disturbed by faults than in the Newport mine. The disturbed strata are perhaps best exposed upon the surface and in a slope sunk in the southwest quarter of section 25, where an utterly fruitless attempt to find coal was made by the same company. Large sums of money have been wasted in the Coos Bay region upon expensive plants before the value of the coal was assured by thorough prospecting. In prospecting any coal field the first step should be to prospect thoroughly the surface outcrops, and if this does not completely settle the commercial value of the deposit, then consideration should be given to the ultimate cost of running an opening as compared with that of boring a hole with a diamond drill to determine what is beneath the surface. The diamond drill in certain cases is a valuable means of prospecting.

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[1] The Coal Mines of the Western Coast of the United States, 1877, pp. 91-92.

[2] Loc. cit., p. 94.

The operators of the Newport mine are boring a hole to determine the composition of the strata underlying that region. The strata are but gently inclined and the conditions are especially favorable for such prospecting. Mr. Campbell, superintendent of the mine, informed me that the drill had passed through 300 feet of sandstone and 500 feet of shale. The sandstone is on top, and the top of the boring is about 100 feet below the Newport coal bed. The intervening rock is sandstone, so that there is positive evidence, in the region of the Newport mine, that no valuable coal occurs within 900 feet below that bed. In the middle portion of the Newport basin the coal is overlain by 100 feet of sandstone, making the measured section, beginning at the top: 100 feet of sandstone, 5 feet of coal, 400 feet of sandstone, and 500 feet of shale. The sandstone core showed many fragments of fossil shells, so that it is known that the rock beneath the coal is full of fossils. Fossils are also abundant in the beds immediately overlying the coal in the Newport mine. In many places they were collected from the roof of the tunnel. Among them Dr. Dall recognized *Lutricola unda* Conr., Ostrea, and Tellina, but none of the forms are sufficiently characteristic to determine the age of the beds. The position of the fossiliferous strata at Marshfield and Jordan Point suggests that the coal beds are of Eocene age, but their gentle inclinations, especially in the Newport basin, and the occurrence of similar rock rich in Miocene fossils to the westward near South Slough, leave their exact geological horizon in doubt.

Coal has been discovered a few miles south of Empire, and also at other points within the Coos Bay region; but a thorough study of this field can not be made until the surveys now in progress shall have been completed.

There is, however, one locality that should be mentioned on account of its geological rather than its economic importance. On the coast, about three-fourths of a mile east of Cape Arago, is a thin bed of coal, from which a number of tons were obtained for use at the Arago lighthouse. It is interstratified with a highly tilted series of shales and thin-bedded sandstones which contain numerous characteristic Eocene fossils, and it is evidently of the same age.

OTHER OUTCROPS OF COAL.

Besides the exposures of coal within the fields already noted, there are numerous other outcrops of greater or less importance within the State. They are usually isolated occurrences, and except in a few cases can not be grouped together.

Mr. William Sharp, who has prospected much for coal in Coos County, has informed me that a bed of coal occurs near the head of Big Creek, in T. 29 S., R. 10 W., and that it crops out on the Middle Fork of the Coquille a short distance west of the mouth of Sandy Creek.

Coal has been reported from Camas Mountain, T. 29 S., R. 8 W., in Douglas County. An analysis of this coal is numbered 31 in the table of analyses.[1] The bed of coal represented by the sample analyzed is reported to be 3 feet thick. It yields red ash and does not coke.

Coal has been found on Smith River in Douglas County, and on several streams which flow into the sea in Lane and Benton counties.

Two years ago Mr. G. J. Callahan opened a seam of coal in sec. 15, T. 27 S., R. 7 W., at the eastern foot of the Coast Range in Douglas County, and obtained from it about 9 tons. Some of the coal was used in a small engine and for blacksmithing, and it is said to have worked well. The seam is 9 inches thick and lies between layers of shale. Its analysis is No. 32 in the list. A calcareous bed overlying the shale a few feet contains numerous Eocene fossils, among which an oyster is quite common.

Of the localities for coal in Douglas County, those on the North Fork of the Umpqua, about 20 miles northeast of Roseburg, are perhaps more widely known than any others. This was made known as early as 1872 by Hugh Small, in his pamphlet on Oregon and Her Resources. The best outcrops are said to be from 2 to 4 miles above Hughes Ferry, and were not visited by the writer. Close to the Ferry and at several points on the East Fork, or Little River, as it is sometimes called, traces of coal are found, but there are no beds of economic importance. At one point on Cavitts Creek, half a mile above its mouth, two small beds of impure coal occur, one 14 inches and the other 3 inches thick. This outcrop was leased for several years to a blacksmith of Myrtle Creek, who is said to have mined several tons for use in his smithy. Analysis No. 33 shows the composition of the coal at this locality.

Good blacksmithing coal has been reported about the headwaters of the Coos River, and in the Coast Range of Yamhill County, as well as at many other points upon both sides of the Willamette Valley. A 4-foot bed, in horizontal sandstone containing leaf impressions, has been noted in Clackamas County, near Wilhoit Springs. Similar outcrops occur at many places along the western foot of the Cascade Range.

In the John Day Valley of eastern Oregon coking coal has been found which yielded the analysis No. 34 of the table. Coal is said to occur also at Pendleton, but so far as yet known the great majority of the outcrops east of the Coast Range, excepting perhaps those of the upper Nehalem basin, are of little commercial importance.

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[1] Tenth Census, Vol. XV, 1880, pp. 788-789.

Concerning the age of the coal-bearing strata of western Oregon, it may be stated that at Pebble Creek (Columbia County), Cape Arago (Coos County), Callahans, and North Fork of the Umpqua (Douglas County) they are definitely known to be of Eocene age; in the Lower Nehalem (Clatsop County) and Yaquina (Lincoln County) coal fields they underlie a considerable thickness of fossiliferous Miocene strata and may be Eocene; at Coos Bay they are so related to both Miocene and Eocene strata that it is not possible without further examination to tell definitely to which they belong, but the tendency of the evidence suggests that they are Eocene.

Chemical analyses of Oregon coals.

No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Physical properties of coke.	Analyst.
1	2.56	46.29	48.49	2.74	......	....	(?)
2	11.16	42.82	41.64	[1] 4.38	4.32	Sooty, incoherent.	Peter Fireman.
3	10.83	41.05	43.17	[1] 4.95	2.47	Partly brilliant and coherent.	Do.
4	10.03	43.40	29.98	[2] 16.59	3.69	Sooty, noncoherent.	Do.
5	12.23	42.47	34.29	[1] 11.01	3.19	.....do	Do.
6	10.07	44.52	32.18	[1] 13.23	3.97	.....do	Do.
7	9.75	32.25	50.50	7.50	......	....	....
8	9.53	42.73	42.29	5.45	......	....	J. H. Fisk and W.H.Hampton.
9	9.00	37.83	45.17	8.00	......	....	Do.
10	19.75	33.20	42.59	4.73	......	....	....
11	8.08	41.26	46.81	[1] 3.85	1.30	Partly brilliant and coherent.	Peter Fireman.
12	8.86	40.06	46.79	[1] 4.29	1.31	Partly brilliant and coherent.	Do.
13	8.91	41.54	47.23	[1] 2.32	0.38	Sooty, slightly coherent.	Do.
14	8.11	41.15	33.59	[1] 17.15	0.95	Sooty, noncoherent.	Do.
15	8.53	39.95	45.79	[1] 5.73	2.00	Partly brilliant and coherent.	Do.
16	15.50	31.40	39.80	13.30	......	....	Sharpless and Winchell.
17	9.12	43.86	42.73	[3] 4.29	0.46	Slightly coherent	Peter Fireman.
18	9.77	43.20	34.22	12.81	2.32	....	Sharpless and Winchell.

[1] Red. [2] Brown. [3] Light brown.

Chemical analyses of Oregon coals—Continued.

No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Physical properties of coke.	Analyst.
19	10.81	46.52	34.26	8.41	......	....	Sharpless and Winchell.
20	12.26	43.16	33.93	10.65	......	....	Do.
21	4.97	42.13	44.91	7.99	1.22	....	Do.
22	5.33	48.31	38.78	9.58	......	....	Do.
23	4.05	46.51	38.15	11.29	......	....	Do.
24	10.42	42.21	43.18	[1]4.19	0.69	Sooty, very slightly coherent.	Peter Fireman.
25	9.78	42.57	44.19	[1]3.46	0.91	Sooty, partly coherent.	J. H. Fisk and W.H.Hampton.
26	11.94	41.48	37.85	[2]8.73	1.32	Sooty, noncoherent.	Do.
27	15.45	41.55	34.95	8.05	2.55	Will not coke....	Thomas Price.
28	17.27	44.15	32.40	6.18	1.37	.....do	Do.
29	11.00	41.00	44.50	3.00	0.45	....	J. A. Fisk and W.H.Hampton.
30	20.09	32.59	41.98	5.34	......	....	Do.
31	1.53	42.82	44.94	10.71	[1]4.49	Does not coke...	F. A. Gooch.
32	1.96	43.68	51.11	[3]3.25	1.66	Partly brilliant and coherent.	Peter Fireman.
33	4.66	38.54	39.00	[4]17.80	0.44	.....do	Do.
34	1.08	24.40	34.71	39.81	0.91	Worthless.......	F. A. Gooch.

[1] Light brown. [2] Red. [3] Brown. [4] Light yellow.

Localities of coals given in foregoing table of analyses.

1. Astoria. Mineral Resources of the United States, 1882, p. 94.

Upper Nehalem coal field, Columbia County:

2. Pebble Creek. Sec. 34, T. 4 N., R. 4 W.
3. Pebble Creek. Sec. 34, T. 4 N., R. 4 W.
4. East Fork of Pebble Creek. Face at interior end of tunnel of Great Northern Coal Company.
5. East Fork of Pebble Creek. S. W. ¼ sec. 23, T. 4 N., R. 4 W. At bottom of canyon.
6. East Fork of Pebble Creek. NW. ¼ sec. 23, T. 4 N., R. 4 W. At bottom of side ravine.
7. East Fork of Pebble Creek. Face of tunnel of Great Northern Coal Company's mine. Published by the company.
8. East Fork of Pebble Creek. Face of tunnel of Great Northern Coal Company's mine. Published by the company.
9. Nehalem No. 1. Location? Published by Great Northern Coal Company.
10. Nehalem No. 2. Location? Published by Great Northern Coal Company.

Lower Nehalem coal field, Clatsop County:

11. Hodge Creek. Sec. 16, T. 3 N., R. 10 W.
12. Hodge Creek. Sec. 16, T. 3 N., R. 10 W.
13. Coal Creek. SW. ¼ sec. 36, T. 4 N., R. 10 W

Yaquina coal field, Lincoln County:

14. Shaw Place, 1¼ miles west of Toledo. Sec. 13, T. 11 S., R. 11 W.
15. Four miles northwest of Toledo. Sec. 30, T. 10 S., R. 10 W.
16. Yaquina Bay. Noted by Sharpless and Winchell.

Coos coal field, Coos County:

17. Riverton coal (Timon's mine).
18. Kight's mine, near Riverton; top.
19. Kight's mine, near Riverton; middle.
20. Kight's mine, near Riverton; bottom.
21. Coquille. Sec. 23, T. 27 S., R. 14 W.; average.
22. Coquille. Sec. 23, T. 27 S., R. 14 W.; above parting.
23. Coquille. Sec. 23, T. 27 S., R. 14 W.; below parting.
24. Beaver Hill mine. Sec. 17, T. 27 S., R. 13 W.
25. Newport mine. Sec. 9, T. 26 S., R. 12 W. Shows distinct woody structure; thrown out by picker.
26. Newport mine. Sec. 9, T. 26 S., R. 12 W. Selected by superintendent.
27. Newport mine, Upper Beach. Sec. 9, T. 26 S., R. 12 W. Mineral Resources of the United States, 1887, p. 289.
28. Newport mine, Lower Beach. Sec. 9, T. 26 S., R. 12 W. Mineral Resources of the United States, 1887, p. 289.
29. Durham. Published by Great Northern Coal Company, of Portland.
30. Coos Bay. Exact location not known. Published by Great Northern Coal Company, of Portland.
31. Camas Mountain, Douglas County. Tenth Census, Vol. XV, p. 788.
32. Callahans, 11 miles west of Roseburg, Douglas County.
33. Near mouth of Cavitts Creek, Douglas County.
34. Blue Mountains. Tenth Census, Vol. XV, p. 788.

HINDRANCES TO THE DEVELOPMENT OF THE COAL FIELDS OF OREGON.

The coal fields of the Coast Range are covered by a growth of vegetation so dense as to greatly interfere with the coal prospector. A luxuriant undergrowth of vines and shrubs amid large numbers of fallen trees in the forests, especially in the ravines, where abundant moisture lingers throughout the summer, completely covers the slopes. The soft sandstone and shales readily crumble to soil, and thus contribute to the more complete covering of the underlying strata. The coal-bearing strata are all soft, like the coal itself, and crop out at the surface only along the lines of most rapid erosion—that is, along streams. In the gulches and ravines of small streams, where the force of the water in floods is not sufficient to sweep away the mass of logs and other rubbish, the outcrops are very few and prospecting is especially tedious; but along the larger streams, as, for example, the Nehalem, which, during freshets sweeps its bed, the rocks are well exposed.

The longer axes of the coal fields are more or less nearly parallel with the trend of the Coast Range, upon whose flanks they occur, and it would be expected that the streams descending from the range across the fields would give fine exposures, but the streams are generally so small that they afford meager outcrops.

While the dense floral covering, by obscuring outcrops, hinders the prospecting of the coal fields, after the mines are once opened the presence of abundant timber is an advantage in supplying the demands of the work.

The greatest hindrance to the development of the Oregon coal fields is the lack of transportation. All the navigable rivers and bays of the Oregon coast are obstructed by bars, which greatly interfere with navigation. Formerly the depth of low water on the bar in front of Coos Bay varied in different seasons, with the shifting bar, from 9 to 13 or 14 feet. Since the jetties have been built, the channel has been improved. In the four years 1881–1885 the number of vessels crossing the bar was 1,118, of which 98 drew more than 13 feet of water. The entrance to Coos Bay is regarded as one of the best along the Oregon coast, the obstacles interposed to navigation by bars at other unimproved places being great.

In the case of the Upper Nehalem coal field, however, development is not hindered by marine obstruction, but by lack of proper facilities for land transportation. Although the coal field is less than 30 miles from Portland, there is a divide between, which, taken in connection with the stream canyons and dense forest, presents considerable difficulty in the way of railroad construction; and until railroad facilities are provided the Upper Nehalem coal field must remain undeveloped.

THE COAL INDUSTRY OF OREGON.

Historical notes.—The only coal of Oregon noted by Prof. James D. Dana in 1841[1] was thin seams in the shale near Astoria. He refers to the coal in the Cowlitz, and reports that "coal is said to occur on the coast north of Oregon and on Vancouver Island." Fourteen years later Prof. J. S. Newberry wrote:[2]

> Although the fact has been frequently announced in the journals, no true coal had been found in California or Oregon at the date of our arrival in San Francisco [May 30, 1855]. About the time of our arrival in San Francisco, however, the carbonaceous deposits on the shores of Coos Bay began to attract the attention of the public, and it was confidently believed that there had at last been found beds of bituminous coal equal in quality to that imported from the Eastern States.

Professor Newberry did not visit Coos Bay, but he saw several cargoes of coal at San Francisco and Portland, and from the information furnished by others he reports as follows:

> This coal is interstratified with sandstones and shales, which form a series several hundred feet in thickness, the strata being very much disturbed by intrusion of trap rock, some of them being inclined at an angle of 45°. The beds of coal are found in the upper part of the series, being most fully developed on the shores of the bay, where the strata are much less disturbed than nearer Cape Arago. * * * Several of the strata associated with the coal are highly fossiliferous, most of the fossils being marine molusca.

From the above statement by Professor Newberry, it is evident that coal was mined at Coos Bay and reached San Francisco as early as 1855. From that time to the present there has been at least one mine in continuous operation. It is interesting to note that in the early report of Professor Newberry the highly inclined beds of Cape Arago were distinguished from the more gently inclined beds on the borders of Coos Bay.

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[1] U. S. Exploring Expedition under Commodore Wilkes. Geology, by J. D. Dana, Vol. X, p. 658.

[2] Reports of Explorations and Surveys for a Railroad from the Mississippi River to the Pacific, Vol. VI, Part II, p. 62.

More detailed information concerning the coal is furnished by R. W. Raymond, who, in 1870, wrote[1] as follows:

> The Coos Bay coal deposit was examined during the year by Mr. William Ashburner, of San Francisco. It is composed of three seams, inclosed in sandstone, dipping toward the northwest at an angle of about 15°. The two principal and lowest seams are each 2 feet 3 inches in thickness, of uniform quality, and separated by an intercalated stratum of sandstone 4 inches thick. The upper seam of coal, being of inferior quality and only 1 foot thick, is not removed by the miners.

Mr. Hugh Small, in 1872, claimed[2] that the Coos Bay mines gave "employment to a regular fleet of schooners that trade to San Francisco and other ports, 60,000 tons being shipped from her mines last year." This large amount indicates considerable activity, and about that time there was great impetus given to coal prospecting in that region; but in 1876, according to Mr. Goodyear,[3] the Eastport and Newport mines were the only ones that had been successfully worked in the Coos Bay region, and of these only the Newport mine has survived.

The following table shows the annual production from 1880 to 1895. These figures are compiled from the volumes of Mineral Resources of the United States, published annually by the United States Geological Survey.

Coal industry in Oregon from 1880 to 1895.

Year.	Number of mines.	Total product in short tons.	Value.	Average price per ton.	Number of days active.	Number of men employed.
1880	......	30,000	....	....	....	....
1881	......	30,000	....	....	....	....
1882	......	30,000	....	....	....	....
1883	......	50,000	....	....	....	....
1884	......	50,000	....	....	....	....
1885	......	44,643	....	....	....	....
1886	......	45,000	$112,500	....	....	....
1887	2	31,696	70,000	$2.75	210	105
1888	2	75,000	225,000	3.00	245	160
1889	2	64,359	163,650	2.60	....	160
1890	1	61,514	177,875	2.89	....	208
1891	1	51,826	155,478	3.00	....	....
1892	1	34,661	148,546	4.29	120	90
1893	1	41,683	164,500	3.57	192	110
1894	1	47,521	183,914	....	243	88
1895	4	73,685	247,901	3.36	69	[4]414

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[1] Mining Statistics West of the Rocky Mountains for 1870, p. 219.

[2] Oregon and Her Resources, 1872.

[3] Coal Mines of the Western Coast, 1877.

[4] The apparently large number of men employed and small average working time is due to the large force of men employed in developing the Beaver Hill mine, which was producing coal for shipment during only 20 days in 1895. The average time made at the Newport mine was over 200 days per man.

It has been stated[1] that the Coos Bay coal commands a better price in San Francisco than any other found on the Pacific Coast, and on the other hand,[2] that it "sells in San Francisco about $2 less per ton than Puget Sound coal of corresponding grade." There is also difference of opinion as to the use for which the coal is best adapted, whether for domestic or for steam-producing purposes. Mr. J. W. Harrison, of San Francisco, informs me by letter, dated December 20, 1895, that the Coos Bay coal is sold "entirely for house uses; being a lignite, it is not sooty, hence is preferred by housekeepers on account of its cleanliness. It is sold in San Francisco at fully 75 cents to $1 per ton less than Australian coal, at $1.25 to $1.50 per ton less than British Columbian coal, and 50 cents per ton less than Seattle coal."

IRON ORES.

The most interesting deposit of iron ore yet discovered in the State, and the only one that has been worked to a considerable extent, is that formerly operated by the Oregon Iron and Steel Company, near Oswego, and about 8 miles south of Portland. The ore is limonite, and lies between sheets of basalt dipping northwest at an angle varying from 20° to 30°. The following section (fig. 17) illustrates the mode of its occurrence. For many of the facts revealed along the drifts and tunnels of this mine I am indebted to Mr. William A. Pomeroy, who resides at the mine. The quotations are from a letter dated February 19, 1896:

> The deposit is in the form of a bed, about 1 mile long and half a mile wide. The strike (nearly parallel with the greatest extent of the ore) is about E. 15° N., and the dip a little west of north. From the surface down the slope for 200 to 400 feet the dip is about 20° to 30°, but diminishes to an average of 8° to 10°. The ore is low-grade limonite or bog ore. It varies somewhat in hardness, color, and composition, owing to the varying amounts of silica and organic matter. The range of analyses is about as follows:

Composition of iron ore from near Oswego, Oreg.

	Per cent.
Metallic iron	30 - 40
Silica	7 - 15
Magnesia	2 - 3
Manganese	4 - 8
Lime	2 - 4
Phosphorus	0.37- 0.67
Sulphur	0.3 - 1

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[1] Statistics of the State of Oregon, by A. J. Dufurs, 1869, p. 101.

[2] Resources of the State of Oregon, collected and prepared by the State Board of Agriculture. Minerals, by Herbert Long, p. 22.

From the southwest part of the outcrop down the dip 800 feet, the ore averages 38 to 45 per cent of metallic iron, contains more alumina, less silica, and is soft and friable. Going east on the outcrop about 1,500 feet, a hard, blackish, flinty, highly siliceous ore is found. It continues down on the dip about 200 feet and is 200 to 300 feet in length. Although there is always more or less of it through the bed in streaks, in some places the whole becomes almost oolitic in appearance, and in those places it is richest. The ore ranges in thickness from 2 to 20 feet, averaging 5 or 6 feet, with the irregular depressions and elevations of the lava surface on which it was deposited.

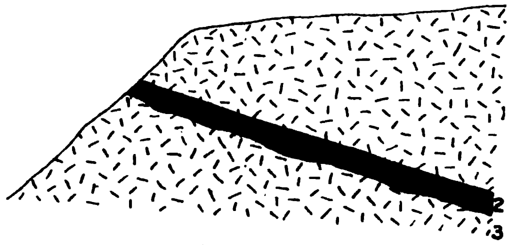

FIG. 17—Section at the Prosser mine. 1, Basalt; 2, Iron-ore bed; 3, Basalt.

As seen by the writer, the bed along the surface ranges from 2 to 8 feet in thickness, and it was traced for about a mile along the strike. The ore seen was generally brown, but varied from black to red. In some cases the red was associated with very siliceous material, reminding one very much of the red jasper found with some of the Lake Superior ores. The following analyses, published in the report of the Tenth Census (Vol. XV, p. 497), shows a somewhat higher percentage of iron than that reported by Mr. Pomeroy:

Percentages of iron and phosphorus in ore from near Oswego, Oreg.

	1165.	1167.	1166.
Metallic iron	44.71	54.19	45.40
Phosphorus	0.666	0.392	0.576
Phosphorus in 100 parts of iron	1.490	0.723	1.269

Specimen 1165 was taken from a pile of 150 tons of ore from the stock house at the furnace. Specimen 1167 was selected chippings of the crystallized ore.

The underlying lava, on whose irregular surface the ore was deposited, is dark-gray basalt, and usually very vesicular, showing that at the time of its extrusion it flowed out upon the surface. It is considerably decomposed in places, and by the process of decomposition oxide of iron is liberated. This fact points to the adjacent lava slopes that surrounded the small lake or swamp in which the ore was deposited as the original source of the iron. By surface streams or chalybeate springs the iron was brought to the lake or swamp, where, under the influence of organic, chemical, or mechanical agents, it was precipitated and accumulated to form the bed of ore.

At some points in the upper part of the ore bed logs are found, but they are most abundant in the sand rock in places immediately overlying the ore. Mr. Pomeroy collected some fossil leaves for me. He writes:

> So far fossils have been found only in the roof, none occurring in the bottom of the bed. At this western part of the bed there is 8 to 14 inches of loose sand rock between the ore body and the hanging. This is found at the outcrop and continues for several hundred feet. The fossils are mostly in this sand rock, which is soft and easily friable, and presents more or less cleavage, some few isolated pieces of wood being found in the ore body itself, but always more or less completely silicified, and near the top. The trees in place have their roots in the sand rock, which is in some places 2 and 3 feet thick. The fallen trees, those in horizontal position, are found with a part of the trunk in the ore and sand rock and part in the hanging. Some of these trees are almost perfect, showing bark and apparently no decay. These trees vary all the way from 5 and 6 inches to 3, 4, 5, and even 6 feet in diameter. They are not found until you go down on the dip about 700 feet, and then they become quite thick, and can be traced east and west almost in a straight line for some distance, evidently showing an old water line.
>
> The fossil leaves in the dark, hard rock came from this locality; those in the lighter, softer rock came from farther up the slope, about 300 to 450 feet from the mouth of tunnel.

After the ore was deposited with the locally overlying bed of sand, and the great forest trees, requiring perhaps centuries for their growth, had developed, the whole accumulation was covered up by another deluge of lava. The lava from this eruption is much more compact and its contact surface much more even than that of the lava below the ore. In type, however, the two rocks are the same, but the eruptions must have been separated by a considerable interval, during which the bed of ore was formed. At that time the upper surface of the ore deposit must have been horizontal, and after the eruption of the lava that covers the deposit, or perhaps in connection with it, the beds were so disturbed as to be tilted at an angle of 20° to 30°. The date of this disturbance has not been fixed, but it certainly belongs to a late geological period. Professor Pumpelly regarded it as probably Tertiary, and states that "similar ores are forming to-day in the great marshes, from the chalybeate waters drained from the decomposing basalts of the Cascade Range."

In order to determine, if possible, the age of the deposit, the fossil leaves collected by Mr. Pomeroy were submitted to Mr. F. H. Knowlton, of the National Museum, for determination. In the small collection he could recognize only a few leaves, which, he says—

> appear to represent a single species of narrow, thick-leaved oak. This is almost the same as *Quercus elænoides* Lx., but differs in having a rounded instead of an obscure acuminate apex. The determination of the age on such imperfect data is obviously unsafe. The specimen of Quercus mentioned above is from the Miocene of California, and the Prosser mine specimens are so close to it, if not indeed identical with it, that it is at most an indication that they may also belong to the Miocene. But more and better material will be necessary before this can be settled definitely.

The ore of the Prosser mine was used in 1865[1] by the Oregon Iron Company in a furnace at Oswego, about 2½ miles from that mine. The mine consists in general of three slightly converging inclines, running down the slope of the bed for nearly a thousand feet, and some of the ore has been taken out upon both sides. The capacity of the mine in 1880 was estimated at 20,000 tons a year. During that year it worked only three and two-thirds months, and yielded 6,225 tons. In June, 1895, the mine was not in operation.

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[1] Mr. J. Ross Browne (Report to the Secretary of the Treasury on the Mineral Resources of the States and Territories west of the Rocky Mountains, 1868), in considering the mineral resources of Oregon, quotes largely from the Oregonian, whose files afford so full a record of the development of the various industries within the State.

Mr. Pomeroy says:

> On the south side, and near the east end of Tualitin Lake, is a deposit of iron ore almost identical with the Prosser ore bed, known as the Patton bed, the dip, strike, foot, and hanging, and ore being almost the same, but it is quite limited in extent. In an air line the two deposits are from 1¼ to 2 miles apart, the deep, narrow lake and swamps intervening.
>
> There is a third, though very small quantity, about 50 feet or more lower in elevation and just east of the Prosser bed, about one-half mile from its east end, where it terminates abruptly against a basaltic ridge or cliff 100 to 150 feet in height. This bed has the same strike, but dips south toward the lake. The ore is very similar to the Prosser ore.

An analysis of ore from one of these localities, taken from the Tenth Census, is given in the last table, column 1167.

Limonite is a widely distributed ore of iron in western Oregon, and is generally associated more or less directly with igneous rocks. The soil of basalts nearly everywhere is full of small, earthy, shot-like concretions, composed of limonite, and their presence in the soil may always be taken as evidence of its derivation from a rock rich in iron.

On the North Fork of the Scappoose, about 25 miles northwest of Portland, a deposit of limonite occurs at the Raffety and Payne mine, from which about 400 tons of ore is said to have been removed. Its outcrop is upon a sharp spur in a short turn of the stream, at an elevation of about 450 feet above the sea, and nearly 300 feet above the stream. There has been no underground work, and the deposit is not well exposed at the opening. It lies between very much decomposed eruptive rocks. Near by, the eruptives are less altered and retain the vesicular character and crystalline structure which clearly indicate their igneous origin. The ore is said to have been traced along a very steep bluff upstream for nearly one-half mile. Mr. Herbert Lang reports[1] the following analysis of the ore at this locality:

Analysis of iron ore from the Raffety and Payne mine, on the North Fork of the Scappoose.

	Per cent.
Silica	1.25
Alumina	5.27
Sulphuric acid	3.22
Phosphoric acid	0.34
Water	15.54
Sesquioxide of iron	74.46
Total	100.08

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[1] The Resources of the State of Oregon, compiled and prepared by the State Board of Agriculture, 1892, p. 26.

We were informed of an iron mine near Mr. West's, on the road from Greenville to Manning, but upon examination found only a ditch with a small quantity of limonite close to a rotten igneous rock. The rock is in general so thoroughly decomposed as to be recognized with difficulty, although in some places its original vesicular structure is still preserved. Mr. West said that some of the ore had been taken to Oregon City and pronounced good. This may well be, but the quantity of ore present appears to be small.

Farther up the West Fork of Dairy Creek, near Manning's, limonite occurs at several localities. At sec. 16, T. 2 N., R. 4 W., a short distance west of Mr. Manning's, there is considerable limonite, like that at Scappoose and Oswego. It is not so clearly associated with eruptive rocks as at Oswego, although basalts, both fresh and altered, occur in that vicinity. Only small pits have been dug in prospecting for the ore. While it is evident that the body of the ore present at this place is not large, it is equally apparent that under favorable circumstances, which do not now exist in that region, it would be worthy of attention. Similar masses of bog ore occur in a swampy tract a short distance southeast of Manning's, and at many points through the country, wherever circumstances were favorable, the oxide of iron resulting from the decomposition of the eruptive rocks accumulated to form deposits of limonite. Fine samples of limonite were seen at the hotel in Vernonia, and several miles southeast of that town is a ferruginous sandstone; but these were not seen in place. Such ore occurs at a number of points in the Coast Range, but all the localities at which it has ever been mined, as far as known to the writer, have been mentioned.

An entirely different class of iron ore occurs among the older rocks of the Klamath Mountains, in the southern part of the State. Mr. Corning, of Corvallis, gave me a fine specimen of magnetite, from Josephine County, in the southern part of the State. Its composition has not been determined. If this ore occurs in abundance at the locality indicated, it will doubtless be of importance some day as a source of iron ore.

Oregon produced a small amount of pig iron in 1894, but reported no iron ore mined.

In 1880 Oregon was seventeenth among 23 iron-producing States.
In 1889 Oregon was nineteenth among 28 iron-producing States.
In 1893 Oregon was twentieth among 25 iron-producing States.

SANDSTONE.

The rocks of the Coast Range of Oregon are chiefly sandstones, shales, and basalts. Although widely distributed, they are not all of economic importance. The shales are of but little use. The calcareous nodules they contain, in some places abundantly, have been burned to lime, but the amount is very limited.

The sandstones are quarried in many places for building purposes. Those near the coast are generally soft, and are used chiefly in the construction of jetties. At Tillamook Bay and Coos Bay they are quarried for this purpose within easy reach of tide water.

The principal sandstone quarry of western Oregon is the one at Pioneer, on the Yaquina River, in Lincoln County. At that place the sandstone occurs in massive beds and affords an excellent building stone. Being soft, it is easily shaped, and yet is durable, with a good, gray color. The heavy beds allow it to be quarried in large pieces, in some cases 10 feet thick. It is carried by railroad from the quarry to tide water, and then towed on barges down the bay. The rock dips gently, and a great mass of it is exposed, so that it will furnish material for some time to come. During 1895 there were many tons of rock shipped from this quarry, and nearly all of it went to San Francisco.

About 5 miles south of Forest Grove, in Washington County, at Boose's quarry, a solid dark-gray sandstone is quarried for building purposes, and is quite extensively used in the surrounding country. The rock contains numerous Miocene fossils.

At several points a few miles south of Corvallis, and at Monroe, still farther south, in Benton County, considerable sandstone has been quarried, but for local use only.

About 2 miles from Jefferson, Marion County, a sandstone has been quarried and used by Mr. F. Wood, of Albany, in the construction of monuments. It is of dark-gray color, easily cut, and occasionally shows upon a fresh fracture irregular areas of bright reflections from the calcareous cement which holds the sand together. The rock, being fine-grained, receives delicate carvings, and was used for the ornamental memorial stone from Oregon in the Washington Monument at the national capital. Small cubes of this sandstone are said to have been tested, and found not only to have a high crushing strength, but to stand fire well. This would be expected from the nature of the sand, which is made up largely of volcanic material. Characteristic fossils occur in this region as well as near Corvallis, showing that the sandstone belongs to the Eocene formation, and may be older than the sandstone at Pioneer and the Coast Range farther northward.

Sandstones are especially abundant in the Coast Range south of the latitude of Eugene City, and are well exposed along the Umpqua and Coos rivers and the forks of the Coquille. A great bluff of sandstone forms the eastern escarpment of the range from Tyee Mountain and Coles Valley to Camas. The same rock continues farther southward, lapping over the older strata, but in places it gets coarser grained, and, rising higher in the mountains, is less available. Along the coast, however, it is much more easily reached. Near Port Orford, and perhaps at other points south of the district embraced in this reconnaissance, the sandstones have been quarried for the San Francisco market.

LIMESTONE AND MARBLE.

It is well known from the publications of Mr. Herbert Lang that limestone, sometimes in the form of marble, occurs in a number of places in the Klamath Mountains of southwestern Oregon, as, for example, near Rocky Point, in Jackson County, and on Williams Creek, in Josephine County. Farther northward, on the borders of the Willamette Valley, in Marion and Polk counties, shell limestone is said to occur.

There is also an interesting occurrence of marble in Douglas County, less than a dozen miles southeast of Roseburg. The narrow belt in which the lenticular masses here and there crop out extend northeast from the Umpqua toward Peel for a distance of at least 20 miles. The outcrops best known are at Cooper's, Flint's, and Whitsett's, and at the quarry of the Variety Marble Company, of Roseburg. At the first two localities it has been burned for lime. At the last locality a mill was erected to saw the marble into slabs, and some of it has been used in Roseburg. The mill was not running in the summer of 1895. The marble is one of remarkable beauty, being handsomely variegated with red, yellow, gray, and white. Much of the rock is mottled gray, with a multitude of white veins, while other portions are brecciated with brilliant shades of red and yellow, veined with white and irregular areas of gray. The marble, when well polished, is one of the most beautiful variegated marbles of this country. It appears, however, that different portions of the mass vary considerably in hardness, rendering it somewhat difficult to work. Furthermore, the quantity exposed at the quarry is quite limited, although farther southward in the same belt larger lenticular masses are exposed.

BASALT.

Under this head are included the modern lavas so extensively used for road metal at many places. At Portland they form a portion of the heights, and they occur at many points throughout western Oregon. This rock forms the falls of the Willamette at Oregon City, and many of the hills throughout the great valley, the fertility of which is largely due to the rich soil furnished by the alteration and disintegration of the lavas.

It is well known that this rock stands among the very best materials obtainable for road construction. In large cities it is sometimes used in the form of paving blocks, but also in the form of fine stones for macadamizing. It is thus employed quite extensively in Portland.

One mile south of Dilley, in Washington County, in this sort of rock, is the county stone quarry for road metal. A crusher is located here, and the crushed stone is hauled a long way. The good roads of that region show the wisdom of such practice.

Basalt is one of the most solid and enduring rocks, but its hardness and tenacity render it comparatively difficult to trim. On account of its somber color it is little used for building, excepting for foundations, and for this purpose it has a wide application. It frequently possesses a columnar jointing that cuts it up into pieces too small for building stone. Occasionally columns are sufficiently regular to be used for fence posts without further trimming. This is especially the case along the Rhine, in Germany.

According to the official report[1] on the stone industry for 1894, granite is quarried in Jackson and Columbia counties; diabase in Linn County; basalt in Clackamas and Linn counties, and andesite in Multnomah County. The value of the granite quarried in Oregon in 1890 was $44,150; in 1891, $3,000; in 1892, $6,000; in 1893, $11,255; in 1894, $4,993. The rocks classed above as granite, diabase, basalt, and andesite are all of igneous origin. In the trade, names of rocks are frequently used without careful discrimination, and they may have to be changed when the rocks are studied.

GOLD.

In recent years the gold-mining industry of western Oregon has been steadily growing in importance. According to the report of the Director of the Mint, the counties west of the Cascade Range ranked as follows in the production of gold in 1894:

Josephine County	$123,676.61
Coos County	109,353.77
Jackson County	107,647.00
Douglas County	70,879.38
Lane County	32,500.00
Curry County	8,800.00
Linn County	5,000.00
Benton County	2,045.00
Marion County	985.00

The profitable production of gold in western Oregon is confined almost exclusively to the areas of the older rocks, such as those of the Klamath Mountains. They are the same as those of the Sierra Nevada of California, which have long been celebrated for their metallic wealth. None of the producing quartz mines lie within the region of this reconnaissance, although much was heard of them, and some fine specimens were seen from the mines in the southern part of Coos County and the eastern part of Lane County, where active mining operations are now being carried on.

Although the greatest production is in the Klamath Mountains, there is at present considerable activity at various points along the western slope of the Cascade Range, as, for example, in the Bohemian region, near the boundary between Lane and Douglas counties, as well as on the McKenzie Fork and at Quartzville, in Marion County.

In the northern portion of the Coast Range, near the borders of Clatsop and Columbia counties, there has been much prospecting, but no productive mines have yet been worked. The Rock Creek mines, which are most easily reached from Vernonia, are located in altered, igneous rocks, closely related to basalt. They are probably of Eocene age, and belong to the mass which forms the core of the Coast Range from Saddle Mountain to Vineyard Hill, near Corvallis. They are considerably changed since their eruption, and while it is possible that they may contain metalliferous deposits of economic value, the presence of these is not yet certainly known.

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[1] Sixteenth Ann. Rept. U. S. Geol. Survey, Pt. IV, pp. 444 and 461.

On the North Fork of Myrtle Creek the placer mines are worked to a very limited extent. These are said to have once been the most extensive placer mines of southern Oregon, and are supposed to have produced upward of $80,000 annually. They lie within the area covered by the Roseburg sheet, and will soon be mapped in detail.

Among the most interesting of the mineral resources of the region embraced within this reconnaissance is the auriferous black sand near the coast. This is found chiefly in Coos County. These sands were carefully studied, over part of the area, in the spring of 1895, by Messrs. Sharpless and Winchell; their report is not yet published, but the writer has been permitted to consult it and quote from it.

Although the writer passed through the same region and visited some of the mines, he remained there only a short time, hoping to avail himself, as he now does, of the results obtained by the detailed observations of Messrs. Sharpless and Winchell. According to these observers, the auriferous black sands occur along the beach for some miles north of the mouth of the Coquille, and extend inland about 2 miles, attaining an altitude, along the eastern margin, of nearly 100 feet above the sea.

The deposits in question are beds of more or less stratified sand and gravel, in which are embedded many trunks and stumps of trees, some of great size, and species, such as redwood, known to exist only in California. The sand consists mainly of grayish-colored silica and feldspar. It also contains garnets, rubies, magnetite, ilmenite, chromite, and metallic gold, platinum, and iridosmine. The washing and blowing of the sand on the beach tends to concentrate the gravel and bowlders into certain strata, and the heavy minerals above-mentioned into others. It thus happens that the bowlders are mainly confined to the lower portion of these sand deposits, while the heavy sand, containing a relatively large percentage of black sand and of the precious metals mentioned, lies just above, in beds which vary in thickness from a few inches to 10 or 12 feet. On top of the black sand is a varying depth of gray sand; near the beach it will vary from 3 or 4 feet to 30 feet, while a mile away from the beach it will vary from 30 to 60 feet.

Gravel streaks occur all through the sand at irregular intervals, but the pebbles in the upper strata are seldom larger than 1 inch in diameter.

The bowlders are of many varieties, but siliceous rocks are most numerous, and those of petrified wood are frequent. It is worthy of note that many of these bowlders of silicified wood are partly or wholly black, indicating that they were partially lignitized before being silicified. Bowlders of porphyry, of diabase, and of other basic siliceous rocks are present, as are also fine greenish conglomerates.

The fine sand contains beautifully perfect crystals of garnet, ruby, and the iron minerals, besides some green mineral not determined.

The gold present in these sands is in the form of minute scales of native gold.

> These yellow scales or flakes frequently assume the shape of small cups or basins, and are thus easily moved by flowing water or moving currents of air. Indeed, when exposed to the air and again immersed in water they will frequently float with persistency on the surface of the liquid, on account of the minute air bubbles which collect upon them. In processes of concentration, whether natural or artificial, they are thus gathered together with the iron minerals of considerably less density, but more compact and rounded form. It is due to this fact that the larger part of the gold is found in the black streaks and layers, while the gray sand contains scarcely any.
>
> The size of these gold flakes or "colors" varies widely, some of them are so small as to be barely visible with the unaided eye, and others are one-sixteenth or even one-eighth of an inch in diameter. On account of their extreme tenuity the prospector is inclined to overestimate the value of the gold in the sand which he is prospecting with a pan. Thus, when from 20 to 30 colors are found in a pan, it is usually concluded that that sand is well worth working, and will run $2 or $3 to the cubic yard. This we found to be a mistaken estimate. As a matter of fact, the value of 600 colors is but 1 cent, and if 200 shovelfuls of 10 pounds each should each yield 30 colors, the value of the ton of sand thus treated would amount to but 10 cents. In this fact lies one fruitful source of disappointed hopes and unsuccessful enterprises in the working of auriferous black sands.
>
> The pan is a convenient prospector's implement, but it gives merely a relative test, and should be checked by some absolute determinations, such as assaying or careful weighing of the colors obtained.

Messrs. Sharpless and Winchell examined many samples of sand, both gray and black, and they say:

> Taking together all of the gray sands, we have 7.2 cents per ton as about the average value. It will be seen from this table that the amount of gold in the gray sand is extremely small—with but two possible exceptions, too small to treat the sands with profit for its recovery. The black sands, however, contain a sufficient quantity of gold to make their treatment a subject worthy of serious consideration.

The average value of ten samples of black sand given in the table referred to above is 55 cents per ton. Some of the samples were from the beach; others were from mines near the eastern limit of the black-sand area. The samples from the beach were much the richest in gold.

> Of the valuable metals contained in the Oregon black sands, platinum is one of some importance. All records go to show that it has been found in greater or less quantity wherever gold has been found on the Pacific Coast. Of the samples taken by ourselves not one of those assayed yielded more than a trace of platinum, but samples from adjoining properties submitted to us for examination, samples that we have every reason to believe were honestly taken, yielded about two-tenths of an ounce per ton in the sand and 3.47 ounces per ton in the concentrates.
>
> Platinum was found at three points by us when panning with the shovel, but, as noted above, only traces were found when the original samples were assayed.
>
> The concentrates which were made while we were on the beach carried no platinum. Of several samples of concentrates made previous to our arrival, and later examined by us, only one carried an appreciable amount of platinum.
>
> We therefore come to the conclusion that the platinum is not distributed in any uniform ratio with the gold through the sand, and can therefore not be depended upon as a constituent of value; at least its presence can not be depended upon so that profit may be calculated from it.
>
> We believe beyond doubt, however, that at some point in the district under consideration the concentrates would show sufficient platinum to pay for its extraction if mining operations were in progress.
>
> One sample of concentrates containing both gold and platinum was treated in

the following manner: The concentrates were allowed to stand under a weak solution of potash twenty-four hours. Mercury was then added, and 92 per cent of the gold was amalgamated; the residue was treated with the magnet to remove magnetic iron, and subsequently concentrated again. The last concentrate was resmelted. The results showed that about 80 per cent of the platinum in the original concentrates was saved, about 10 per cent was carried with the magnetic iron, and about 10 per cent was washed away by water in the reconcentration. While this method is accompanied by a loss of 20 per cent of the metal, it is so simple that a concentrate carrying twenty-five one-hundredths of an ounce of platinum per ton can be treated with profit. A more complete extraction would be obtained by direct smelting or by amalgamating in an acid solution, but the accompanying cost would prohibit the treatment of any material carrying less than 1 ounce per ton.

Chemical examination of the black sands of California and Oregon has frequently shown the presence of small quantities of the metals iridium and osmium, in some cases occurring as iridosmium, and in others alloyed with platinum in varying proportions. Our examination failed to show any appreciable quantity of these metals, so we do not think that their presence can be relied upon as a source of profit. A sample of concentrates submitted by Mr. Smith from an adjoining claim showed over an ounce of iridosmium per ton. When working on an extensive scale, the concentrates would probably often show traces of these metals, and when present in very small quantities they would pay for extraction.

Iridium is quoted at about $15 per ounce, and osmium at $60 per ounce. These metals would be recovered with and in the same manner as the platinum.

Sharpless and Winchell considered the value of the ores of iron and chromite in the black sand, and also a possible use of the black sand in the manufacture of abrasives, but came to the conclusion that at present they are of little if any value to those working the black sands.

The auriferous black sands along the coasts of Oregon and California have been known for many years, and many attempts have been made to extract the gold, but it is so fine that nearly all efforts to save it have failed. Within the last few years a machine, known as the "Rossman concentrator," has been constructed and successfully used in the northern part of Curry County. The same apparatus was tested by Sharpless and Winchell with good results, and in their report they fully describe the machine as affording the most promising method known at present of recovering the valuable contents of the black sand.

In September, 1895, when the writer visited the Pioneer mine, on the road between Empire and Bandon, in Coos County, active preparations were being made to use the Rossman concentrator. The mine used to be known as the Lane mine, and is now operated by C. F. Allen, J. A. Rupert, and several associates. It is located near the head of a ravine about a mile and a half from the ocean, at an elevation of less than 100 feet. The layer of black sand is about 5 feet thick, and is usually richest near the bottom. An ordinary shovelful, panned upon the shovel itself, yielded about 40 colors. The sand at this point is evenly stratified and looks as if regularly water-laid. At the base of the black sand are occasional logs, in which the wood is well preserved. Mr. F. H. Knowlton has examined a specimen of the wood from one of these logs and pronounces it redwood, which at the present time is not known to grow north of the California line.

Three samples of the black sand were taken from the black-sand layer; one near the bottom, another near the middle, and a third near the top. The samples were small, and not intended for quantitative analyses, the chief aim being to get a general idea of its mineralogical composition, leaving a more detailed investigation until the maps of the region are completed. Although the black sand is generally composed of essentially the same minerals, they vary in relative abundance from place to place. It is remarkably beautiful when viewed under a microscope, owing to the great variety and brilliancy of the colors.

The sample from the basal portion of the layer in the Pioneer mine is composed chiefly of garnet, magnetite, ilmenite, and chromite, with a smaller amount of staurolite, zircon, epidote, and gold. In determining the mineralogical composition of the sand, it was first divided into two portions by means of a small hand magnet. Some of the magnetic material gave a strong reaction for titanium. so that ilmenite as well as magnetite is present.

The nonmagnetic portion of the sand still contained a large number of lustrous coal-black grains intermingled with pale purple and clear red grains, and a smaller proportion of reddish-yellow and colorless or pale yellowish and yellowish-green grains. Treated for a number of hours over a water bath with hydrofluoric and sulphuric acid, the purplish and clear red grains, as well as the yellowish-green ones, disappeared, but the others were not appreciably affected.

Under the microscope the purplish and clear red grains are found to be completely isotropic, indicating that they are isometric, and probably garnet, of which they have the luster and hardness. The purplish grains are usually angular; but of the red variety, rounded grains and well-defined trapezohedral crystals are most common. They look like rubies, but are distinguished by their form and chemical reactions. When fused with carbonate of soda and treated with nitric acid they yield a pink solution, due to the presence of manganese, hardly deep enough in color, however, to indicate spessartite. The purplish grains treated in the same way did not give a decided reaction for manganese.

The greenish-yellow grains, when crushed, are found to be pleochroic, from colorless to light yellow, and yield brilliant colors between crossed nicols, suggesting that the grains are epidote.

The acid reaction noted above removes the ilmenite and magnetite, but leaves a dark mineral which crystallizes in regular octahedrons with truncated edges. When crushed it is found to be brown in transmitted light, and with salts of phosphorus gives a strong reaction for chromium, showing that it is either picotite or chromite.

The colorless to pale yellowish mineral is generally in wheat-shaped grains, thick in the middle and tapering both ways, with ends well rounded by attrition, but occasionally the crystal terminations are well preserved. The mineral is infusible and doubly refracting, with parallel extinction. The crystals are generally in the form of square prisms with simple pyramidal terminations like zircon, but occasionally forms like that illustrated by Dana (Text-book of Mineralogy, 1877, p. 283), from McDowell County, N. C., appear.

The reddish-yellow grains are infusible, do not become magnetic, and have a specific gravity below 4. Between crossed nicols they yield brilliant colors, and are pleochroic, like staurolite, from honey to reddish yellow.

It is probable that there are other minerals in the sand, but in the small amount examined these were the only ones seen.

Gold is much less abundant than any of the other minerals already mentioned, but yet so plenty that a small shovelful yielded 30 to 50 minute colors. No platinum or iridosmine was seen. In searching for these minerals, 80 grams of sand was taken and reduced by fusion with potassium bisulphate and potassium fluoride, but no certain trace of either metal was found. This is not to be wondered at, when we consider the variability in the composition of the sand and the small amount treated.

An assay was made of the same material, but only a trace of gold was found, and no platinum.

The source of the black sand is to be found in the crystalline rocks of the Klamath Mountains, which, like those of the Sierra Nevada of California, part of the west slope of the Cascade Range, and the Blue Mountains of eastern Oregon, belong to the auriferous slate series. These rocks contain not only the gold, but the silver, nickel, platinum, and other rarer precious metals, besides a large portion of the iron ore, and on this account the Klamath Mountains and the Blue Mountains must be regarded as the most important sources of metalliferous wealth in the State of Oregon.

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